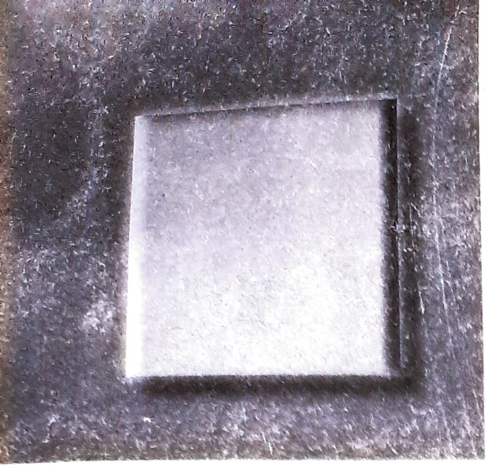

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CHAPTER

1

Thermometry, Thermal Expansion and Calorimetry

DPP 1.1

Thermometry and Thermal Expansion

Single Correct Answer Type

1. When a copper ball is heated, the largest percentage increase will occur in its
(a) Diameter
(b) Area
(c) Volume
(d) Density

2. When a bimetallic strip is heated, it
(a) does not bend at all
(b) gets twisted in the form of an helix
(c) bend in the form of an arc with the more expandable metal outside
(d) bends in the form of an arc with the more expandable metal inside

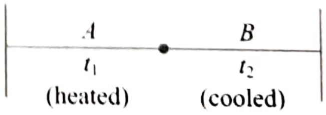
3. At some temperature T, a bronze pin is a little large to fit into a hole drilled in a steel block. The change in temperature required for an exact fit is minimum when
(a) only the block is heated
(b) both block and pin are heated together
(c) both block and pin are cooled together
(d) only the pin is cooled

4. If the length of a cylinder on heating increases by 2%, the area of its base will increase by
(a) 0.5%
(b) 2%
(c) 1%
(d) 4%

5. A solids floats submerged in a liquid. When the liquid is heated, which of the following is most likely to happen?
(a) Solid may sink
(b) Solid may float with a part outside the surface
(c) Solid may first sink and then rise upwards
(d) Solid may oscillate vertically

6. A uniform metal rod is used as a bar pendulum. If the room temperature rises by 10°C, and the coefficient of linear expansion of the metal of the rod is 2×10^{-6} per °C, the period of the pendulum will have percentage increase of
(a) -2×10^{-3}
(b) -1×10^{-3}
(c) 2×10^{-3}
(d) 1×10^{-3}

7. Two wires A and B of the same cross-sectional areas, Young's moduli Y_1 and Y_2 and coefficients of linear expansion α_1 and α_2, respectively, are joined together and fixed between rigid supports at either ends. The tension in the compound wire when wire A is heated and wire B is cooled at different temperature is same when wire A alone is cooled at the same temperature as wire B earlier. Find the correct option.



(a) $\frac{\alpha_1}{\alpha_2} > \frac{Y_2}{2Y_1}$ (b) $\frac{\alpha_1}{\alpha_2} < \frac{Y_2}{2Y_1}$

(c) $\frac{\alpha_1}{\alpha_2} > \frac{2Y_2}{Y_1}$ (d) $\frac{\alpha_1}{\alpha_2} > \frac{Y_2}{Y_1}$

8. If on heating liquid through 80°C, the mass expelled is $(1/100)^{\text{th}}$ of mass still remaining, the coefficient of apparent expansion of liquid is

(a) 1.25×10^{-4}/°C (b) 12.5×10^{-4}/°C

(c) 1.25×10^{-5}/°C (b) None of these

9. A glass flask of volume one litre at 0°C is filled, level full of mercury at this temperature. The flask and mercury are now heated to 100°C. How much mercury will spill out if the coefficient of volume expansion of mercury is 1.82×10^{-4}/°C and the linear expansion of glass is 0.1×10^{-4}/°C, respectively?

(a) 21.2 cc (b) 15.2 cc

(c) 1.52 cc (d) 2.12 cc

10. A steel scale measures the length of a copper wire as 80.0 cm when both are at 20°C (the calibration temperature for scale). What would be the scale read for the length of the wire when both are at 40°C? (Given $\alpha_{\text{steel}} = 11 \times 10^{-6}$ per °C and $\alpha_{\text{copper}} = 17 \times 10^{-6}$ per °C)

(a) 80.0096 cm (b) 80.0272 cm

(c) 1 cm (d) 25.2 cm

11. A piece of metal weight 46 gm in air, when it is immersed in the liquid of specific gravity 1.24 at 27°C it weighs 30 gm. When the temperature of liquid is raised to 42°C the metal piece weight 30.5 gm, specific gravity of the liquid at 42°C is 1.20, then the linear expansion of the metal will be

(a) 3.316×10^{-5}/°C (b) 2.316×10^{-5}/°C

(c) 4.316×10^{-5}/°C (d) None of these

12. The coefficient of linear expansion of crystal in one direction is α_1 and that in every direction perpendicular to it is α_2. The coefficient of cubical expansion is

(a) $\alpha_1 + \alpha_2$ (b) $2\alpha_1 + \alpha_2$

(c) $\alpha_1 + 2\alpha_2$ (d) None of these

Multiple Correct Answers Type

13. A metallic circular disc having a circular hole at its centre rotates about an axis passing through its centre and perpendicular to its plane. When the disc is heated

(a) its angular velocity will decrease

(b) its diameter will decrease

(c) its moment of inertia will increase

(d) its speed will increase

14. Due to thermal expansion, with rise in temperature:

(a) metallic scale reading becomes lesser than true value

(b) pendulum clock becomes fast

(c) a floating body sinks a little more

(d) the weight of a body in a liquid increases.

Fill in the Blanks Type

15. Oxygen boils at –183°C. This temperature in Fahrenheit scale is approximately............

16. Recently, the phenomenon of superconductivity has been observed at 95 K. This temperature Fahrenheit scale is nearly equal to ....

17. The temperature of a substance increases by 27°C. On the Kelvin scale, this increase is equal to.........

18. Maximum density of H_2O is at the temperature in Fahrenheit scale ....

19. The temperature of a body on Kelvin scale is found to be x K. When it is measured by Fahrenheit thermometer, it is found to be x°F. Then the value of x is............

20. A centigrade and a Fahrenheit thermometer are dipped in boiling water. The water temperature is lowered until the Fahrenheit thermometer registers 140°. The fall in temperature as registered by the Centigrade thermometer is ....

21. The centigrade (Celsius) and Fahrenheit readings are same at ....

22. On centigrade scale, the temperature of a body increases by 30 degrees. The increase in temperature on Fahrenheit scale is ....

Answers Key

Single Correct Answer Type

1. (c) **2.** (c) **3.** (a) **4.** (d) **5.** (a)

6. (d) **7.** (b) **8.** (a) **9.** (b) **10.** (a)

11. (b) **12.** (c)

Multiple Correct Answers Type

13. **(a, c)** **14.** **(a, c)**

Fill in the Blanks Type

15. –297°F **16.** –288°F **17.** 27 K

18. 39.2°F **19.** 574.25 **20.** 60°

21. –40° **22.** 54°

DPP 1.2

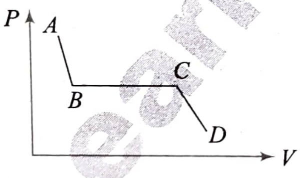
Calorimetry

Subjective Type

1. Four cubes of ice at –10°C, each one gm, is taken out from the refrigerator and are put in 150 gm of water at 20°C. Find the temperature of water when thermal equilibrium is attained. Assume that no heat is lost to the outside and the water equivalent of container is 46 gm. (Specific heat capacity of water = 1 cal/gm-°C, specific heat capacity of ice = 0.5 cal/gm-°C, latent heat of fusion of ice = 80 cal/gm-°C)
2. An ice block at 0°C and of mass m is dropped from height 'h' such that the loss in gravitational potential energy of block is exactly equal to the heat required to just completely melt the ice. Taking latent heat of fusion of ice = 80 cal/gm, acceleration due to gravity = 10 m/s^2 and mechanical equivalent of heat = 4.2 J/Cal. Find the value of 'h'.

Single Correct Answer Type

3. The portion AB of the indicator diagram representing the state of matter denotes
   (a) the liquid state of matter
   (b) gaseous state of matter
   (c) change from liquid to gaseous state
   (d) change from gaseous state to liquid state



4. If two balls of same metal weighing 5 gm and 10 gm strike with a target with the same velocity. The heat energy so developed is used for raising their temperature alone. Then the temperature will be higher
   (a) for bigger ball
   (b) for smaller ball
   (c) equal for both the balls
   (d) None is correct from the above three
5. How many grams of a liquid of specific heat 0.2 at a temperature 40°C must be mixed with 100 gm of a liquid of specific heat of 0.5 at a temperature 20°C, so that the final temperature of the mixture becomes 32°C?
   (a) 175 gm (b) 300 g (c) 295 gm (d) 375 g
6. 1 g of steam at 100°C melts how much ice at 0°C? (Latent heat of ice = 80 cal/gm and latent heat of steam = 540 cal/gm)
   (a) 1 gm (b) 2 gm (c) 4 gm (d) 8 gm
7. One kilogram of ice at 0°C is mixed with one kilogram of water at 80°C. The final temperature of the mixture is (Take: specific heat of water = 4200 J kg^{-1} K^{-1}, latent heat of ice = 336 kJ kg^{-1})
   (a) 40°C (b) 60°C (c) 0°C (d) 50°C
8. A hammer of mass 1 kg having speed of 50 m/s hits an iron nail of mass 200 gm. If the specific heat of iron is 0.105 cal/gm°C and half the energy is converted into heat, the raise in the temperature of nail is
   (a) 7.1°C (b) 9.2°C (c) 10.5°C (d) 12.1°C
9. The amount of heat (in calories) required to convert 5 gm of ice at 0°C to steam at 100°C is
   (a) 3100 (b) 3200 (c) 3600 (d) 4200
10. A vessel contains 110 g of water. The heat capacity of the vessel is equal to 10 g of water. The initial temperature of water in vessel is 10°C. If 220 g of hot water at 70°C is poured in the vessel, the final temperature neglecting radiation loss will be
    (a) 70°C (b) 80°C (c) 60°C (d) 50°C
11. A system S receives heat continuously from an electric heater of power 10 W. The temperature of S becomes constant at 50°C when the surrounding temperature is 20°C. After the heater is switched off, S cools from 35.1°C to 34.9°C in 1 minute. The heat capacity of S is
    (a) 100 J/°C (b) 300 J/°C
    (c) 750 J/°C (d) 1500 J/°C
12. Equal volumes of water and alcohol when put in similar calorimeters take 100 sec and 74 sec, respectively, to cool from 50°C to 40°C. The thermal capacity of each calorimeter is numerically equal to the volume of either liquid. The specific gravity of alcohol is 0.8. If the specific heat capacity of water is 1 cal/gm, the specific heat capacity of alcohol will be
    (a) 0.6 cal/gm-°C (b) 0.8 cal/gm-°C
    (c) 1.6 cal/gm-°C (d) 1.8 cal/gm-°C
13. A thermally insulated vessel contains some water at 0°C. The vessel is connected to a vacuum pump to pump out water vapour. This results in some water getting frozen. It is given latent heat of vaporization of water at 0°C = 21 × 10^5 J/kg and latent heat of freezing of water = 3.36 × 10^5 J/kg. The maximum percentage amount of water vapour that will be solidified in this manner will be
    (a) 86.2% (b) 33.6% (c) 21% (d) 24.36%

Multiple Correct Answers Type

14. When m gm of water at 10°C is mixed with m gm of ice at 0°C, which of the following statements are false?
(a) The temperature of the system will be given by the equation $m \times 80 + m \times 1 \times (T - 0) = m \times 1 \times (10 - T)$.
(b) Whole of ice will melt, and temperature will be more than 0°C but lesser than 10°C.
(c) Whole of ice will melt and temperature will be 0°C.
(d) Whole of ice will not melt, and temperature will be 0°C.

Fill in the Blanks Type

15. 540 g of ice at 0°C is mixed with 540 g of water at 80°C. The final temperature of the mixture is........

16. Heat required to convert one gram of ice at 0°C into steam at 100°C is..............
(given $L_{\text{steam}} = 536$ cal/gm)

17. 80 gm of water at 30°C is poured on a large block of ice at 0°C. The mass of ice that melts is................

18. Two spheres made of same substance have diameters in the ratio 1 : 2. Their thermal capacities are in the ratio of......

19. Work done in converting one gram of ice at −10°C into steam at 100°C is.................

20. A body of mass 5 kg falls from a height of 30 metre. If its all mechanical energy is changed into heat, then heat produced will be ....

21. In supplying 400 calories of heat to a system, the work done will be ....

22. 0.93 watt-hour of energy is supplied to a block of ice weighing 10 gm. It is found that ....

Answers Key

Subjective Type

1. 17.9°C **2.** 33.6 km

Single Correct Answer Type

3. (a) **4.** (c) **5.** (d) **6.** (d) **7.** (c)
8. (a) **9.** (c) **10.** (d) **11.** (d) **12.** (a)
13. (a)

Multiple Correct Answers Type

14. (a, b, c)

Fill in the Blanks Type

15. 0°C **16.** 716 cal **17.** 30 gm
18. 1 : 8 **19.** 3045 J **20.** 350 cal
21. 1672 J **22.** the entire block just melts

CHAPTER 2

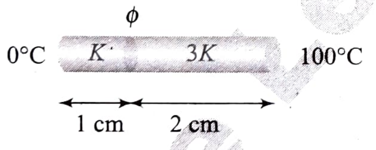
Transmission of Heat

DPP 2.1

Transmission of Heat (Conduction)

Single Correct Answer Type

1. Two bars of thermal conductivities K and $3K$ and lengths 1 cm and 2 cm, respectively, have equal cross-sectional area. They are joined length wise as shown in the figure. If the temperature at the ends of this composite bar is 0°C and 100°C, respectively (see figure), then the temperature ϕ of the interface is



(a) 50°C (b) $\frac{100}{3}$°C (c) 60°C (d) $\frac{200}{3}$°C

2. A wall is made up of two layers A and B. The thickness of the two layers is the same, but materials are different. The thermal conductivity of A is double than that of B. In thermal equilibrium, the temperature difference between the two ends is 36°C. Then the difference of temperature at the two surfaces of A will be

(a) 6°C (b) 12°C (c) 18°C (d) 24°C

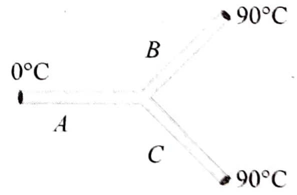
3. A cylinder of radius R made of a material of thermal conductivity K_1 is surrounded by a cylindrical shell of inner radius R and outer radius $2R$ made of material of thermal conductivity K_2. The two ends of the combined system are maintained at two different temperatures. There is no loss of heat across the cylindrical surface and the system is in steady state. The effective thermal conductivity of the system is

(a) $K_1 + K_2$ (b) $\frac{K_1K_2}{K_1 + K_2}$

(c) $\frac{K_1 + 3K_2}{4}$ (d) $\frac{3K_1 + K_2}{4}$

4. Three rods made of the same material and having the same cross section have been joined as shown in the figure. Each rod is of the same length. The left and right ends are kept at 0°C and 90°C respectively. The temperature of the junction of the three rods will be

(a) 45°C (b) 60°C (c) 30°C (d) 20°C



5. Ice has formed on a shallow pond, and a steady state has been reached, with the air above the ice at –5.0°C and the bottom of the pond at 4.0°C. If the total depth of ice + water is 1.4 m (assume that the thermal conductivities of ice and water are 0.40 and 0.12 cal/m °C s, respectively), the thickness of ice layer is

(a) 1.1 m (b) 0.4 m (c) 2.1 m (d) 3.6 m

6. Two identical conducting rods are first connected independently to two vessels, one containing water at

100°C and the other containing ice at 0°C. In the second case, the rods are joined end to end and connected to the same vessels. Let q_1 and q_2 g/s be the rate of melting of ice in two cases respectively. The ratio of q_1/q_2 is

(a) $\frac{1}{2}$ (b) $\frac{2}{1}$ (c) $\frac{4}{1}$ (d) $\frac{1}{4}$

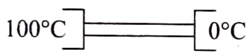
7. A solid cube and a solid sphere of the same material have equal surface area. Both are at the same temperature 120°C. Then

(a) Both the cube and the sphere cool down at the same rate
(b) The cube cools down faster than the sphere
(c) The sphere cools down faster than the cube
(d) Whichever is having more mass will cool down faster

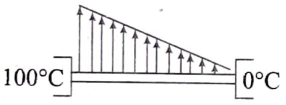
8. The two opposite faces of a cubical piece of iron (thermal conductivity = 0.2 CGS units) are at 100°C and 0°C in ice. If the area of a surface is 4 cm^2, then the mass of ice melted in 10 minutes will be

(a) 30 gm (b) 300 gm (c) 5 gm (d) 50 gm

9. A conducting cylindrical rod of uniform cross-sectional area is kept between two large chambers which are at temperatures 100°C and 0°C, respectively. The conductivity of the rod increases with x, where x is distance from 100°C end. The temperature profile of the rod in steady-state will be as



(a)



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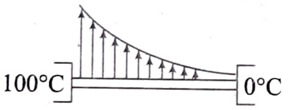

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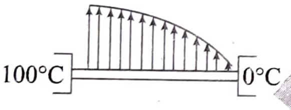
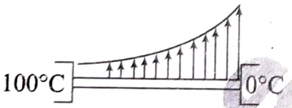
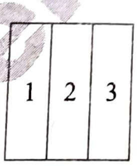


(d)

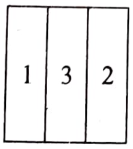


Multiple Correct Answers Type

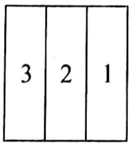
10. The figure shows three different arrangements of materials 1, 2 and 3 (identical in shape) to form a wall. The thermal conductivities are K_1, K_2 and K_3, respectively, and $K_1 > K_2 > K_3$. The left side of the wall is 20°C higher than the right side.



(I)



(II)



(III)

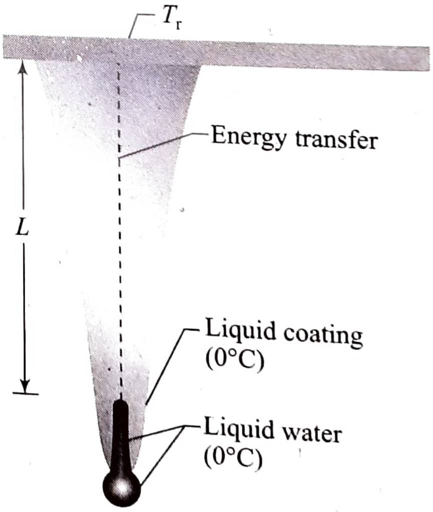
(a) In steady state, the rate of energy conduction through the wall III is greatest.
(b) In steady state, the rate of energy conduction through all the walls (I), (II) and (III) are same.
(c) In steady state, temperature difference across material 1 is greatest in wall II.
(d) In steady state, temperature difference across material 1 is same in all the walls.

11. The ends of a rod of uniform thermal conductivity are maintained at different (constant) temperatures. After the steady state is achieved:

(a) heat flows in the rod from high temperature to low temperature even if the rod has non-uniform cross-sectional area.
(b) temperature gradient along length is same even if the rod has non-uniform cross-sectional area.
(c) heat current is same even if the rod has non-uniform cross-sectional area.
(d) if the rod has uniform cross-sectional area the temperature is same at all points of the rod.

Comprehension Type

Liquid water coats an active (growing) icicle and extends up a short, narrow tube along the central axis. Because the water-ice interface must have a temperature of 0°C, the water in the tube cannot lose energy through the sides of the icicle or down through the tip because there is no temperature change in those directions. It can lose energy and freeze only by sending energy up (through distance L) to the top of the icicle, where the temperature T_r can be below 0°C. Take $L = 0.10$ m and $T_r = -5$°C. Assume that the central tube and the upward conduction path both have cross-sectional area $A = 0.5$ m^2. The thermal conductivity of ice is 0.40 W/m·K, latent heat of fusion is $L_F = 4.0 \times 10^5$ J/k and the density of liquid water is 1000 kg/m^3.



12. The rate at which the energy conducted upward is

(a) 20 W (b) 15 W (c) 5 W (d) 10 W

13. The rate at which mass converted from liquid to ice at the top of the central tube is

(a) 7.5×10^{-3} kg/s (b) 2.5×10^{-5} kg/s
(c) 5×10^{-3} kg/s (d) 5×10^{-5} kg/s

14. At what rate does the top of the tube move downward because of water freezing there?

(a) 5×10^{-8} m/s (b) 2.5×10^{-3} m/s
(c) 2.5×10^{-8} m/s (d) 4.5×10^{-2} m/s

Fill in the Blanks Type

15. The thermal conductivity of a material in CGS system is 0.4. In steady state, the rate of flow of heat is 10 cal/sec-cm². Then the thermal gradient will be ....

16. Two vessels of different materials are similar in size in every respect. The same quantity of ice filled in them gets melted in 20 minutes and 30 minutes. The ratio of their thermal conductivities will be ....

17. Two walls of thicknesses d_1 and d_2 and thermal conductivities K_1 and K_2 are in contact. In the steady state, if the temperatures at the outer surfaces are T_1 and T_2, the temperature at the common wall is ....

18. Two identical plates of different metals are joined to form a single plate whose thickness is double the thickness of each plate. If the coefficients of conductivity of each plate are 2 and 3, respectively, then the conductivity of composite plate will be...............

19. The ratio of the diameters of two metallic rods of the same material is 2 : 1 and their lengths are in the ratio 1 : 4. If the temperature difference between their ends are equal, the rate of flow of heat in them will be in the ratio..........

20. Two cylinders P and Q have the same length and diameter and are made of different materials having thermal conductivities in the ratio 2: 3. These two cylinders are combined to make a cylinder. One end of P is kept at 100°C and another end of Q at 0°C. The temperature at the interface of P and Q is ....

Answers Key

Single Correct Answer Type

1. (c) **2.** (b) **3.** (c) **4.** (b) 5. (a)
6. (c) 7. (b) **8.** (b) 9. (b)

Multiple Correct Answers Type

10. (b, d) **11. (a, c)**

Comprehension Type

12. (d) **13.** (b) **14.** (c)

Fill in the Blanks Type

15. 25°C/cm
16. 1.5
17. $\dfrac{K_1T_1d_2 + K_2T_2d_1}{K_1d_2 + K_2d_1}$
18. 2.4
19. 16 : 1
20. 40°C

DPP 2.2

Transmission of Heat (Radiation—Kirchhoff's Law, Wein's Law and Stefan's Law)

Single Correct Answer Type

1. Half part of ice block is covered with black cloth and rest half is covered with white cloth and then it is kept in sunlight. After some time clothes are removed to see the melted ice. Which of the following statements is correct?
   (a) Ice covered with white cloth will melt more.
   (b) Ice covered with black cloth will melt more.
   (c) Equal ice will melt under both clothes.
   (d) It will depend on the temperature of surroundings of ice.
2. Two thermometers *A* and *B* are exposed in sun light. The valve of *A* is painted black, but that of *B* is not painted. The correct statement regarding this case is
   (a) Temperature of *A* will rise faster than *B* but the final temperature will be the same in both
   (b) Both *A* and *B* show equal rise in beginning
   (c) Temperature of *A* will remain more than *B*
   (d) Temperature of *B* will rise faster
3. When *p* calories of heat is given to a body, it absorbs *q* calories; then the absorption power of body will be
   (a) p/q (b) q/p (c) p^2/q^2 (d) q^2/p^2
4. The total energy radiated from a black body source is collected for one minute and is used to heat a quantity of water. The temperature of water is found to increase from 20°C to 20.5°C. If the absolute temperature of the black body is doubled and the experiment is repeated with the same quantity of water at 20°C, the temperature of water will be
   (a) 21°C (b) 22°C (c) 24°C (d) 28°C
5. The surface temperature of the Sun is T_0 and it is at average distance *d* from a planet. The radius of the Sun is *R*. The temperature at which planet radiates the energy is
   (a) $T_0\sqrt{\frac{R}{2d}}$ (b) $T_0\sqrt{\frac{2R}{d}}$
   (c) $T_0\sqrt{\frac{R}{d}}$ (d) $T_0\left(\frac{R}{d}\right)^{1/4}$
6. In the previous problem, if θ is the angle subtended by the Sun at the planet, then temperature at which planet radiates energy is proportional to
   (a) θ (b) θ^2 (c) $\theta^{1/2}$ (d) $\theta^{-1/2}$
7. The power radiated by a black body is *P*, and it radiates maximum energy around the wavelength λ_0. If the temperature of the black body is now changed so that it radiates maximum energy around a wavelength $3\lambda_0/4$, the power radiated by it will increase by a factor of
   (a) 4/3 (b) 16/9 (c) 64/27 (d) 256/81

Multiple Correct Answers Type

8. A heated body emits radiation which has maximum intensity at frequency ν_m. If the temperature of the body is doubled:
   (a) the maximum intensity radiation will be at frequency $2\nu_m$
   (b) the maximum intensity radiation will be at frequency $(1/2)\nu_m$
   (c) the total emitted energy will increase by a factor 16
   (d) the total emitted energy will increase by a factor 2
9. The solar constant for a planet is *S*. The surface temperature of the sun is *TK*. The sun subtends an angle θ at the planet:
   (a) $S \propto T^4$ (b) $S \propto T^3$
   (c) $S \propto \theta^2$ (d) $S \propto \theta$

Comprehension Type

A body is kept inside a container the temperature of the body is T_1 and the temperature of container is T_2. The rate at which body absorbs the energy is α. The emissivity of the body is *e*. The radiation striking the body is either absorbed or reflected.

10. After a long time, the temperature of the body will be:
    (a) T_1 (b) T_2
    (c) $T_1 + \frac{(T_2 - T_1)}{2}$ (d) None of these
11. At what rate, the body will emit the radiant energy?
    (a) if *t* is the time, rate is $(T_1 - T_2)/t$
    (b) *e*
    (c) Both of the above
    (d) None of the above
12. At what rate the body will absorb the radiant energy?
    (a) α, but $\alpha \neq e$
    (b) $(T_1 - T_2)/t$, where *t* is the time
    (c) *e*, but $e = \alpha$
    (d) None of the above

13. A good absorber is
(a) good reflector
(b) poor reflector
(c) average reflector
(d) Assessment not possible

Fill in the Blanks Type

14. If wavelengths of maximum intensity of radiations emitted by the sun and the moon are 0.5×10^{-6} m and 10^{-4} m respectively, the ratio of their temperatures is............

15. A black body emits radiations of maximum intensity at a wavelength of 5000 Å, when the temperature of the body is 1227°C. If the temperature of the body is increased by 1000°C, the maximum intensity of emitted radiation would be observed at ....

16. The intensity of radiation emitted by the sun has its maximum value at a wavelength of 510 nm and that emitted by the north star has the maximum value at 350 nm. If these stars behave like black bodies, then the ratio of the surface temperature of the sun and north star is........

17. A black body radiates energy at the rate of E W/m^2 at a high temperature T K. When the temperature is reduced to $\frac{T}{2}$ K, the radiant energy will be.......

18. Energy is being emitted from the surface of a black body at 127°C temperature at the rate of 1.0×10^6 J/sec-m^2. Temperature of the black body at which the rate of energy emission is 16.0×10^6 J/sec–m^2 will be............

19. The rectangular surface of area 8 cm × 4 cm of a black body at a temperature of 127°C emits energy at the rate of E per second. If the length and breadth of the surface are each reduced to half of the initial value and the temperature is raised to 327°C, the rate of emission of energy will become ....

Answers Key

Single Correct Answer Type

1. (b) **2.** (a) **3.** (b) **4.** (d) **5.** (a)
6. (c) **7.** (d)

Multiple Correct Answers Type

8. (a, c) **9.** (a, c)

Comprehension Type

10. (b) **11.** (b) **12.** (c) **13.** (b)

Fill in the Blanks Type

14. 200 **15.** 3000 Å **16.** 0.69 **17.** $\frac{E}{16}$
18. 527°C **19.** $\frac{81}{64}E$

DPP 2.3

Radiation—Newton's Law of Cooling

Single Correct Answer Type

1. Consider two hot bodies B_1 and B_2 which have temperatures 100°C and 80°C, respectively, at $t = 0$. The temperature of the surroundings is 40°C. The ratio of the respective rates of cooling R_1 and R_2 of these two bodies at $t = 0$ will be
(a) $R_1 : R_2 = 3 : 2$ (b) $R_1 : R_2 = 5 : 4$
(c) $R_1 : R_2 = 2 : 3$ (d) $R_1 : R_2 = 4 : 5$

2. Equal masses of two liquids are filled in two similar calorimeters. The rate of cooling will
(a) Depend on the nature of the liquids
(b) Depend on the specific heats of liquids
(c) Be same for both the liquids
(d) Depend on the mass of the liquids

3. A body takes 4 min to cool from 100°C to 70°C. To cool from 70°C to 40°C it will take (room temperature is 15°C)
(a) 7 min (b) 6 min
(c) 5 min (d) 4 min

4. A body cools from 60°C to 50°C in 10 minutes. If the room temperature is 25°C and assuming Newton's law of cooling to hold good, the temperature of the body at the end of the next 10 minutes will be
(a) 38.5°C (b) 40°C (c) 42.85°C (d) 45°C

5. The temperature of a liquid drops from 365 K to 361 K in 2 minutes. Find the time during which temperature of the liquid drops from 344 K to 342 K. Temperature of room is 293 K
(a) 84 sec (b) 72 sec (c) 66 sec (d) 60 sec

6. Hot water kept in a beaker placed in a room cools from 70°C to 60°C in 4 minutes. The time taken by it to cool from 69°C to 59°C will be
(a) The same 4 minutes (b) More than 4 minutes
(c) Less than 4 minutes (d) We cannot say definitely

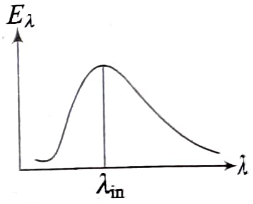
7. In a room where the temperature is 30°C, a body cools from 61°C to 59°C in 4 minutes. The time (in min) taken by the body to cool from 51°C to 49°C will be
(a) 4 min (b) 6 min (c) 5 min (d) 8 min

8. A calorimeter of mass 0.2 kg and specific heat 900 J/kg-K. Containing 0.5 kg of a liquid of specific heat 2400 J/kg-K. Its temperature falls from 60°C to 55°C in one minute. The rate of cooling is
(a) 5 J/s (b) 15 J/s (c) 100 J/s (d) 115 J/s

9. A cane is taken out from a refrigerator at 0°C. The atmospheric temperature is 25°C. If t_1 is the time taken to heat from 0°C to 5°C and t_2 is the time taken from 10°C to 15°C, then
(a) $t_1 > t_2$ (b) $t_1 < t_2$
(c) $t_1 = t_2$ (d) There is no relation

Comprehension Type

The radiations emitted by the sun are analyzed and the spectral energy distribution curve is plotted, as shown. The radius of the sun is R, the earth is situated at a distance 'd' from the sun. Treat the sun as perfectly black body which radiates power at constant rate till its store of hydrogen gets exhausted. (Stefan's constant = σ, Wien's constant = b, speed of light = c)



10. Assume the sun produces energy only by nuclear fusion of hydrogen nuclei and the fraction of nuclear mass of hydrogen that can be converted to energy is η. How long will the sun keep on emitting the energy if the mass of hydrogen at present in Sun's core is m?
(a) $\dfrac{\eta mc^2\lambda_m^4}{\pi R^2\sigma b^4}$ (b) $\dfrac{\eta mc^2\lambda_m^4}{4\pi R^2\sigma b^4}$
(c) $\dfrac{\eta mc^2\lambda_m^4}{2\pi R^2\sigma b^4}$ (d) $\dfrac{2\eta mc^2\lambda_m^4}{\pi R^2\sigma b^4}$

11. If the earth is at a distance 'd' from the sun the intensity of light falling on the earth (called solar constant S) is
(a) $S = \sigma\left(\dfrac{R}{d}\right)^2\left(\dfrac{b}{\lambda_m}\right)^4$ (b) $S = \sigma\left(\dfrac{R}{d}\right)\left(\dfrac{b}{\lambda_m}\right)^4$
(c) $S = 2\sigma\left(\dfrac{R}{d}\right)^2\left(\dfrac{b}{\lambda_m}\right)^4$ (d) $S = \sigma/2\left(\dfrac{R}{d}\right)^2\left(\dfrac{b}{\lambda_m}\right)^4$

Answers Key

Single Correct Answer Type

1. (a) **2.** (b) **3.** (b) **4.** (c) **5.** (a)
6. (b) **7.** (b) **8.** (d) **9.** (b)

Comprehension Type

10. (b) **11.** (a)

CHAPTER

3

Kinetic Theory of Gases

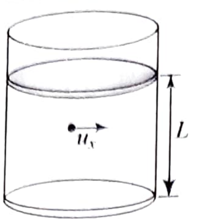
DPP 3.1

Kinetic Theory of Gases

Single Correct Answer Type

1. The pressure P, volume V and temperature T of a gas in the jar A and the other gas in the jar B at pressure $2P$, volume $V/4$ and temperature $2T$, then the ratio of the number of molecules in the jar A and B will be
   (a) 1 : 1 (b) 1 : 2 (c) 2 : 1 (d) 4 : 1
2. At what temperature is the root mean square velocity of gaseous hydrogen molecules is equal to that of oxygen molecules at 47°C
   (a) 20 K (b) 80 K (c) –73 K (d) 3 K
3. Gas at a pressure P_0 in contained as a vessel. If the masses of all the molecules are halved and their speeds are doubled, the resulting pressure P will be equal to
   (a) $4P_0$ (b) $2P_0$ (c) P_0 (d) $\frac{P_0}{2}$
4. The root mean square speed of the molecules of a diatomic gas is v. When the temperature is doubled, the molecules dissociate into two atoms. The new root mean square speed of the atom is
   (a) $\sqrt{2}v$ (b) v (c) $2v$ (d) $4v$
5. The molecules of a given mass of a gas have a rms velocity of 200 m/sec at 27°C and 1.0×10^5 N/m^2 pressure. When the temperature is 127°C and pressure is 0.5×10^5 N/m^2, the rms velocity in m/sec will be
   (a) $\frac{100\sqrt{2}}{3}$ (b) $100\sqrt{2}$
   (c) $\frac{400}{\sqrt{3}}$ (d) None of these
6. Which of the following statement is true?
   (a) Absolute zero degree temperature is not zero energy temperature.
   (b) Two different gases at the same temperature pressure have equal root mean square velocities.
   (c) The rms speed of the molecules of different ideal gases. maintained at the same temperature are the same.
   (d) Given sample of 1 cc of hydrogen and 1 cc of oxygen both at N.T.P., oxygen sample has a large number of molecules.
7. At which of the following temperature would the molecules of a gas have twice the average kinetic energy they have at 20°C
   (a) 40°C (b) 80°C (c) 313°C (d) 586°C
8. A vessel contains a mixture of one mole of oxygen and two moles of nitrogen at 300 K. The ratio of the average rotational kinetic energy per O_2 molecule to that per N_2 molecule is
   (a) 1 : 1 (b) 1 : 2 (c) 2 : 1
   (d) Depends on the moments of inertia of the two molecules
9. Three closed vessels A, B and C are at the same temperature T and contain gases which obey the Maxwellian distribution of velocities. Vessel A contains only O_2, B only N_2 and C a mixture of equal quantities of O_2 and N_2. If the average speed of the O_2 molecules in vessel A is V_1, that of the N_2 molecules in vessel B is V_2, the average speed of the O_2 molecules in vessel C is (where M is the mass of an oxygen molecule)
   (a) $(V_1 + V_2)/2$ (b) V_1
   (c) $(V_1V_2)^{1/2}$ (d) $\sqrt{kT/M}$

Comprehension Type



Suppose there are N molecules each of mass m, of an ideal gas in a container. The x component of velocity of a molecule is denoted by u_x. The gas is enclosed using a horizontal piston of area A as shown.

10. The pressure of the gas is

(a) $\frac{m\langle u_x^2\rangle N}{AL}$ (b) $\frac{m\langle u_x^2\rangle N}{3AL}$

(c) $\frac{3m\langle u_x^2\rangle N}{AL}$ (d) $\frac{3m\langle u_x^2\rangle}{AL}$

11. The pressure of the gas can also be written in terms of momentum transferred per collision (Δp) and collision frequency (f) on the wall of area A as

(a) $\Delta p \times f$ (b) $\frac{\Delta p}{A \times f}$

(c) $\frac{\Delta p \times f}{A}$ (d) None of these

12. If the temperature of gas is doubled keeping volume constant, we know from the gas law that the pressure will be doubled. On microscopic level this increase in pressure is because

(a) momentum change per collision is doubled while the frequency of collision remains constant
(b) momentum change per collision remains constant while the frequency of collision is doubled
(c) momentum change per collision and the frequency of collision both are increased
(d) none of these two physical quantities are changed. It is due to some other reason.

13. If the piston is moved so as to reduce the volume of gas by half, keeping the temperature of gas constant, we know from the gas law that the pressure will be doubled. On microscopic level the increase in pressure on the piston is because

(a) momentum change per collision is doubled while the frequency of collision remains constant
(b) momentum change per collision remains constant while the frequency of collision is doubled
(c) momentum change per collision and the frequency of collision both are increased
(d) none of these two physical quantities are changed. It is due to some other reason.

14. If the piston is moved in so as to reduce the volume of gas by half, keeping the temperature of gas constant, we know from the gas law that the pressure will be doubled. On microscopic level the increase in pressure on the **vertical side walls** is because

(a) momentum change per collision is doubled while the frequency of collision remains constant
(b) momentum change per collision remains constant while the frequency of collision is doubled
(c) momentum change per collision and the frequency of collision both are increased
(d) none of these two physical quantities are changed. It is due to some other reason.

Fill in the Blanks Type

15. The root mean square speed of hydrogen molecules of an ideal hydrogen gas kept in a gas chamber at 0°C is 3180 m/s. The pressure on the hydrogen gas is ....
(Density of hydrogen gas is 8.99×10^{-2} kg/m^3, 1 atmosphere = 1.01×10^5 N/m^2)

16. A cylinder of capacity 20 litres is filled with H_2 gas. The total average kinetic energy of translatory motion of its molecules is 1.5×10^5 J. The pressure of hydrogen in the cylinder is ......

17. A flask contains 10^{-3} m^3 gas. At a temperature, the number of molecules of oxygen are 3.0×10^{22}. The mass of an oxygen molecule is 5.3×10^{-26} kg and at that temperature the rms velocity of molecules is 400 m/s. The pressure in N/m^2 of the gas in the flask is........

18. When volume of system is increased two times and temperature is decreased half of its initial temperature, then pressure becomes............

19. Let A and B the two gases and given: $\frac{T_A}{M_A} = 4 \cdot \frac{T_B}{M_B}$; where T is the temperature and M is the molecular mass. If C_A and C_B are the rms speed, then the ratio $\frac{C_A}{C_B}$ will be equal to......

20. The rms speed of the molecules of a gas in a vessel is 400 ms^{-1}. If half of the gas leaks out at constant temperature, the rms speed of the remaining molecules will be.........

21. The root mean square speed of hydrogen molecules at 300 K is 1930 m/s. Then the root mean square speed of oxygen molecules at 900 K will be..............

22. The speeds of 5 molecules of a gas (in arbitrary units) are as follows: 2, 3, 4, 5, 6. The root mean square speed for these molecules is..............

Answers Key

Single Correct Answer Type

1. (d) **2.** (a) **3.** (b) **4.** (c) **5.** (c)
6. (a) **7.** (c) **8.** (a) **9.** (b)

omprehension Type

10. (a) **11.** (c) **12.** (c) **13.** (b) **14.** (d)

Fill in the Blank Type

15. 3.0 atm **16.** 5×10^6 N/m^2 **17.** 8.48×10^4 N/m^2
18. 1/4 times **19.** 2 **20.** 400 ms^{-1}
21. 836 m/s **22.** 4.24

DPP 3.2

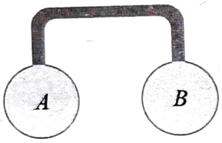
Ideal Gas Equation

Single Correct Answer Type

1. Suppose ideal gas equation follows VP^3 = constant. Initial temperature and volume of the gas are T and V, respectively. If gas expands to $27V$, then its temperature will be come

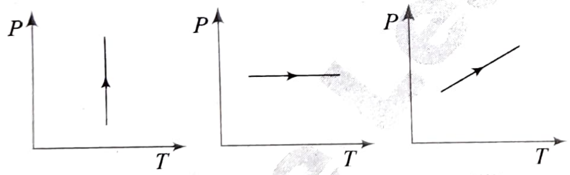
(a) T (b) $9T$ (c) $27T$ (d) $T/9$

2. Two spherical vessels of equal volume, are connected by a n arrow tube. The apparatus contains an ideal gas at one atmosphere and 300 K. Now if one vessel is immersed in a bath of constant temperature 600 K and the other in a bath of constant temperature 300 K. Then the common pressure will be



(a) 1 atm (b) $\frac{4}{5}$ atm (c) $\frac{4}{3}$ atm (d) $\frac{3}{4}$ atm

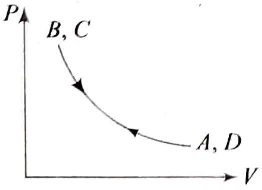
3. Pressure versus temperature graphs of an ideal gas are as shown in figure. Choose the wrong statement

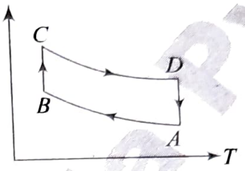


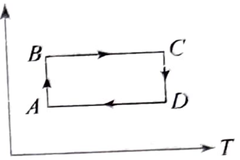
(i) (ii) (iii)

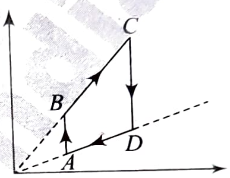
(a) Density of gas is increasing in graph (i)
(b) Density of gas is decreasing in graph (ii)
(c) Density of gas is constant in graph (iii)
(d) None of these

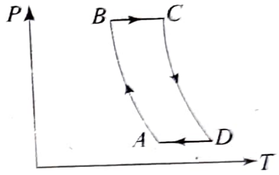
4. Density vs volume graph is shown in the figure. Find corresponding pressure vs temperature graph:



(a)


(b)


(c)


(d)


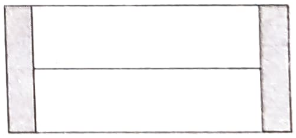
5. The initial temperature of a gas is 100°C. The gas is contained in closed vessel. If the pressure of the gas is increased by 5%, calculate the increase in temperature of the gas:

(a) 1°C (b) 2°C (c) 4°C (d) 5°C

6. A closed hollow insulated cylinder is filled with gas at 0°C and also contains an insulated piston of negligible weight and negligible thickness at the middle point. The gas on one side of the piston is heated to 100°C. If the piston moves 5 cm the length of the hollow cylinder is

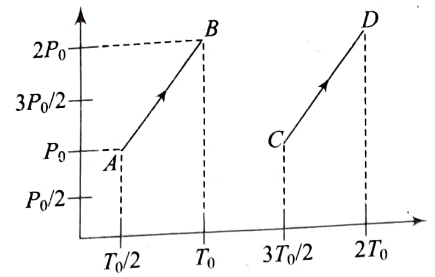
(a) 13.65 cm (b) 27.3 cm
(c) 38.6 cm (d) 64.6 cm

7. The air tight and smooth pistons of a cylindrical vessel are connected with a string, as shown, initially pressure and temperature of the gas are P_0 and T_0. The atmospheric pressure is also P_0. At a later time, tension in the string is $\frac{3}{8}P_0A$ where A is the cross-sectional are of the cylinder. At this time, the temperature of the gas has become:



(a) $\frac{3}{8}T_0$ (b) $\frac{3}{4}T_0$ (c) $\frac{11}{8}T_0$ (d) $\frac{13}{8}T_0$

8. P–T graph for same number of moles of two ideal gases are shown. Find the path along which volume decreases.



(a) A to B (b) B to A

(c) C to D (d) D to C

9. A vessel of volume $V = 30$ litre is separated into three equal parts by stationary semi permeable membranes. The left, middle and right parts are filled with $m_H = 30$ gm of hydrogen, $m_{O_2} = 160$ gm of oxygen and $m_N = 70$ gm of nitrogen respectively. The left partition lets through only hydrogen while the right partition lets through hydrogen and nitrogen. If the temperature in all is 300 K, the ratio of pressure in the three compartments will be:

(a) 4 : 9 : 5 (b) 1.3 : 4.5 : 2

(c) 9 : 4 : 5 (d) 9: 5 : 4

Multiple Correct Answers Type

10. A steel tank contains 300 g of ammonia gas (NH_3) at a pressure of 1.35×10^6 Pa and a temperature of 77°C. Later the temperature is 22°C and the pressure is 8.7×10^5 Pa.

(a) the initial volume of the tank is 38 liters.

(b) finally 71 g grams of gas will leak out of the tank.

(c) the number of moles of the remaining gas is13.5 mol.

(d) the number of moles of the remaining gas is 8.5 mol.

11. Which of the following quantities is independent of the nature of the gas at same temperature?

(a) The number of molecules in 1 mole

(b) The number of molecules in equal volume

(c) The translational kinetic energy of 1 mole

(d) The kinetic energy of unit mass

12. Which of the following quantities depend on temperature only for a given ideal gas?

(a) Internal energy of the gas

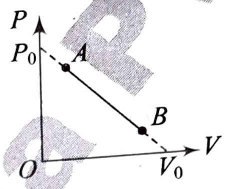
(b) Product PV of the gas

(c) The ratio of pressure and density of the gas

(d) Root mean square speed of the gas

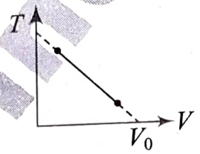
Comprehension Type

One mole of an ideal monatomic gas undergoes a linear process from A to B, in which is pressure P and its volume V change as shown in figure

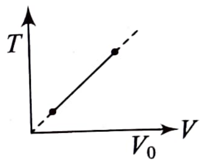


13. The absolute temperature T versus volume V for the given process is

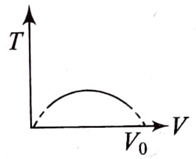
(a)



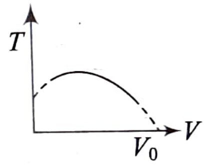
(b)



(c)



(d)



14. The maximum temperature of the gas during this process is

(a) $\dfrac{P_0V_0}{2R}$ (b) $\dfrac{P_0V_0}{4R}$

(c) $\dfrac{3P_0V_0}{4R}$ (d) $\dfrac{3P_0V_0}{2R}$

Answers Key

Single Correct Answer Type

1. (b) 2. (c) 3. (c) 4. (c) 5. (d)

6. (d) 7. (c) 8. (c) 9. (b)

Multiple Correct Answers Type

10. (a, b, c) 11. (a, c) 12. (c, d)

Comprehension Type

13. (c) 14. (b)

CHAPTER 4

Thermodynamics

DPP 4.1

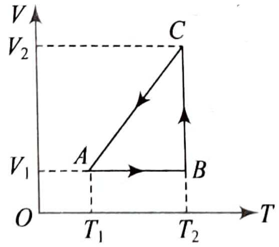
Work Done in Thermodynamic Process

Subjective Type

1. One mole of an ideal gas is warmed slowly so that it goes from the PV state (P_i, V_i) to $(3P_i, 3V_i)$ in such a way that the pressure of the gas is directly proportional to the volume. (a) How much work is done on the gas in the process? (b) How is the temperature of the gas related to its volume during this process?
2. An ideal gas is taken through a quasi-static process described by $P = \alpha V^2$, with $\alpha = 5.00$ atm/m^6, The gas is expanded to twice its original volume of 1.00 m^3. How much work is done by the gas in expanding gas in this process?

Single Correct Answer Type

3. A cyclic process for 1 mole of an ideal gas is shown in figure in the V–T, diagram. The work done in AB, BC and CA respectively, is



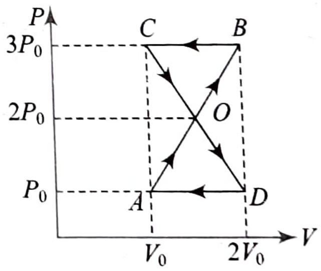
(a) $0, RT_2 \ln\left(\frac{V_1}{V_2}\right), R(T_1 - T_2)$

(b) $R(T_1 - T_2), 0, RT_1 \ln\frac{V_1}{V_2}$

(c) $0, RT_2 \ln\left(\frac{V_2}{V_1}\right), R(T_1 - T_2)$

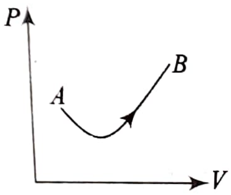
(d) $0, RT_2 \ln\left(\frac{V_2}{V_1}\right), R(T_2 - T_1)$

4. A thermodynamic system undergoes cyclic process $ABCDA$ as shown in figure. The work done by the system is



(a) P_0V_0 (b) $2P_0V_0$ (c) $\frac{P_0V_0}{2}$ (d) Zero

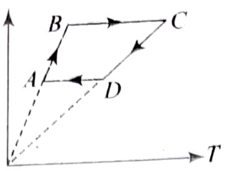
5. Consider a process shown in the figure. During this process the work done by the system



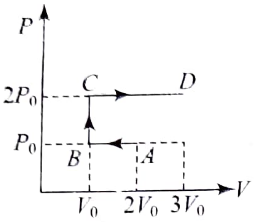
(a) Continuously increases
(b) Continuously decreases
(c) First increases, then decreases
(d) First decreases, then increases

6. Six moles of an ideal gas performs a cycle shown in figure. If the temperature are $T_A = 600$ K, $T_B = 800$ K, $T_C = 2200$ K and $T_D = 1200$ K, the work done per cycle is

(a) 20 kJ (b) 30 kJ
(c) 40 kJ (d) 60 kJ



7. P-V diagram of an ideal gas is as shown in figure. Work done by the gas in process *ABCD* is

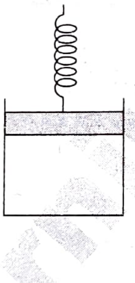


(a) $4P_0V_0$ (b) $2P_0V_0$
(c) $3P_0V_0$ (d) P_0V_0

8. A gas expands with temperature according to the relation $V = kT^{2/3}$. What is the work done when the temperature changes by 30°C

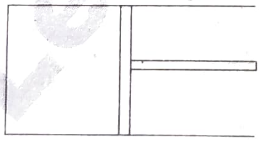
(a) 10 *R* (b) 20 *R* (c) 30 *R* (d) 40 *R*

9. One mole of an ideal gas is kept enclosed under a light piston (area = 10^{-2} m^2) connected by a compressed spring (spring constant 100 N/m). The volume of gas is 0.83 m^3 and its temperature is 100 K. The gas is heated so that it compresses the spring further by 0.1 m. The work done by the gas in the process is: (Take $R = 8.3$ J/K-mole and suppose there is no atmosphere).



(a) 3 J (b) 6 J (c) 9 J (d) 1.5 J

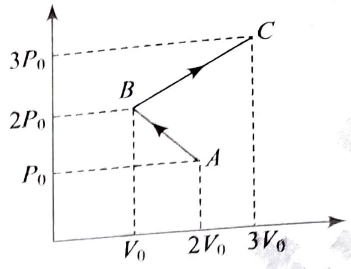
10. *n* moles of a gas filled in a container at temperature *T* is in thermodynamic equilibrium initially. If the gas is compressed slowly and isothermally to half its initial volume the work done by the atmosphere on the piston is:



(a) $\frac{nRT}{2}$ (b) $-\frac{nRT}{2}$

(c) $nRT\left(\ln 2 - \frac{1}{2}\right)$ (d) $-nRT \ln 2$

11. Find the work done by the gas in the process *ABC*.



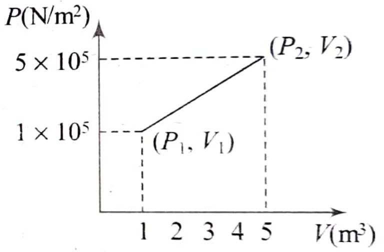
(a) $\frac{3}{2}P_0V_0$ (b) $\frac{5}{2}P_0V_0$ (c) $\frac{7}{2}P_0V_0$ (d) $4P_0V_0$

Fill in the Blanks Type

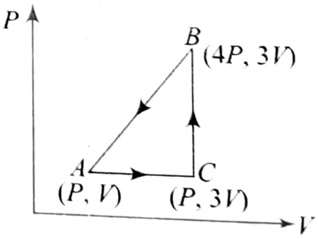
12. In an isothermal reversible expansion, if the volume of 96 gm of oxygen at 27°C is increased from 70 litres to 140 litres, then the work done by the gas will be ....

13. 540 calories of heat convert 1 cubic centimeter of water at 100°C into 1671 cubic centimeter of steam at 100°C at a pressure of one atmosphere. Then the work done against the atmospheric pressure is nearly............

14. A system changes from the state (P_1, V_1) to (P_2, V_2) as shown in the figure. The work done by the system is ......



15. A sample of ideal monoatomic gas is taken round the cycle *ABCA* as shown in the figure. The work done during the cycle is ....



Answers Key

Subjective Type

1. (a) $-4P_iV_i$ (b) $T = \left(\frac{P_i}{nRV_i}\right)V^2$ **2.** 1.18 MJ

Single Correct Answer Type

3. (d) **4.** (d) **5.** (a) **6.** (c) **7.** (c)
8. (b) **9.** (d) **10.** (a) **11.** (c)

Fill in the Blanks Type

12. $2.3 \times 900\, R \log_{10} 2$ **13.** 40 cal
14. 12×10^5 J **15.** 3*PV*

DPP 4.2

First Law of Thermodynamics and Different Processes

Single Correct Answer Type

1. We consider a thermodynamic system. If ΔU represents the increase in its internal energy and W the work done by the system, which of the following statements is true
(a) $\Delta U = -W$ in an adiabatic process
(b) $\Delta U = W$ in an isothermal process
(c) $\Delta U = -W$ in an isothermal process
(d) $\Delta U = W$ in an adiabatic process

2. When heat is given to a gas in an isobaric process, then
(a) the work is done by the gas
(b) internal energy of the gas increases
(c) both (a) and (b)
(d) none from (a) and (b)

3. Which of the following is correct in terms of increasing work done for the same initial and final state?
(a) Adiabatic < Isothermal < Isobaric
(b) Isobaric < Adiabatic < Isothermal
(c) Adiabatic < Isobaric < Isothermal
(d) None of these

4. When an ideal diatomic gas is heated at constant pressure, the fraction of the heat energy supplied which increases the internal energy of the gas is

(a) $\frac{2}{5}$ (b) $\frac{3}{5}$ (c) $\frac{3}{7}$ (d) $\frac{5}{7}$

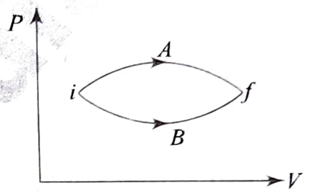
5. The molar heat capacity in a process of a diatomic gas if it does a work of $Q/4$ when a heat of Q is supplied to it is

(a) $\frac{2}{5}R$ (b) $\frac{5}{2}R$ (c) $\frac{10}{3}R$ (d) $\frac{6}{7}R$

6. An insulator container contains 4 moles of an ideal diatomic gas at temperature T. Heat Q is supplied to this gas, due to which 2 moles of the gas are dissociated into atoms but temperature of the gas remains constant. Then
(a) $Q = 2RT$ (b) $Q = RT$
(c) $Q = 3RT$ (d) $Q = 4RT$

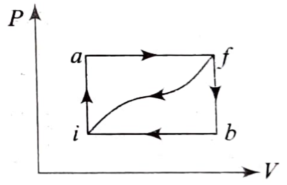
7. Which one of the following gases possesses the largest internal energy
(a) 2 moles of helium occupying 1 m^3 at 300 K
(b) 56 kg of nitrogen at 10^7 Nm^{-2} and 300 K
(c) 8 grams of oxygen at 8 atm and 300 K
(d) 6×10^{26} molecules of argon occupying 40 m^3 at 900 K

8. In the figure given two processes A and B are shown by which a thermo-dynamical system goes from initial to final state F. If ΔQ_A and ΔQ_B are respectively the heats supplied to the systems then



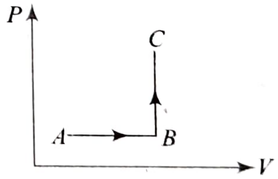
(a) $\Delta Q_A = \Delta Q_B$ (b) $\Delta Q_A \geq \Delta Q_B$
(c) $\Delta Q_A < \Delta Q_B$ (d) $\Delta Q_A > \Delta Q_B$

9. When a system is taken from state i to a state f along path iaf, $Q = 50$ J and $W = 20$ J. Along path ibf. $Q = 35$ J. If $W = -13$ J for the curved return path $f\,i$, Q for this path is



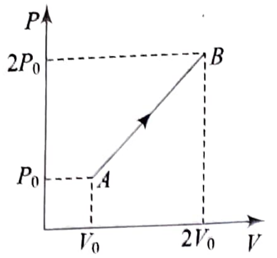
(a) 33 J (b) 23 J (c) −7 J (d) −43 J

10. The P-V diagram of a system undergoing thermodynamic transformation is shown in figure. The work done by the system in going from $A \rightarrow B \rightarrow C$ is 30 J and 40 J heat is given to the system. The change in internal energy between A and C is



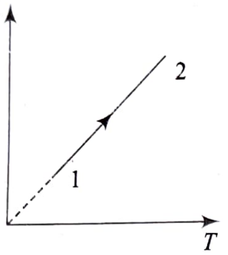
(a) 10 J (b) 70 J (c) 84 J (d) 134 J

11. The P-V diagram of 2 gm of helium gas for a certain process $A \rightarrow B$ is shown in the figure. What is the heat given to the gas during the process $A \rightarrow B$?



(a) $4P_0V_0$ (b) $6P_0V_0$ (c) $4.5P_0V_0$ (d) $2P_0V_0$

12. The volume versus temperature graph of two moles of helium gas is as shown in figure. The ratio of heat absorbed and the work done by the gas in process 1-2 is



(a) 3 (b) $\frac{5}{2}$ (c) $\frac{5}{3}$ (d) $\frac{7}{2}$

13. Heat is supplied to a diatomic gas at constant pressure. The ratio of $\Delta Q : \Delta U : \Delta W$ is

(a) 5 : 3 : 2 (b) 5 : 2 : 3
(c) 7 : 5 : 2 (d) 7 : 2 : 5

14. *N* moles of an ideal diatomic gas are in a cylinder at temperature *T*. Suppose on supplying heat to the gas, its temperature remains constant but *n* moles get dissociated into atoms. Heat supplied to the gas is

(a) Zero (b) $\frac{1}{2}nRT$
(c) $\frac{3}{2}nRT$ (d) $\frac{3}{2}(N-n)RT$

Fill in the Blanks Type

15. In a thermodynamic process, pressure of a fixed mass of a gas is changed in such a manner that the gas molecules gives out 20 J of heat and 10 J of work is done on the gas. If the initial internal energy of the gas was 40 J, then the final internal energy will be

16. A perfect gas goes from state *A* to another state *B* by absorbing 8×10^5 J of heat and doing 6.5×10^5 J of external work. It is now transferred between the same two states in another process in which it absorbs 10^5 J of heat. Then in the second process work done on the gas is..........

17. The specific heat of a gas in an isothermal process is.....

18. A thermally insulated container is divided into two parts by a screen. In one part the pressure and temperature are *P* and *T* for an ideal gas filled. In the second part it is vacuum. If now a small hole is created in the screen, then the temperature of the gas will................

19. When an ideal gas in a cylinder was compressed isothermally by a piston, the work done on the gas was found to be 1.5×10^4 joules. During this process, about............ of heat flowed out from the gas

20. In adiabatic expansion ΔU is .....(positive/negative/zero)

21. A gas at NTP is suddenly compressed to one-fourth of its original volume. If γ is supposed to be 3/2, then the final pressure is............

22. An ideal gas at 27°C is compressed adiabatically to 8/27 of its original volume. If $\gamma = 5/3$, then the rise in temperature is...............

23. Two identical samples of a gas are allowed to expand (i) isothermally (ii) adiabatically. Work done is......... (less/more/equal) in the isothermal process

24. During the adiabatic expansion of 2 moles of a gas, the internal energy of the gas is found to decrease by 2 J. The work done during the process on the gas will be equal to..............

Answers Key

Single Correct Answer Type

1. (a) **2.** (c) **3.** (a) **4.** (d) **5.** (c)
6. (b) **7.** (b) **8.** (d) **9.** (d) **10.** (a)
11. (b) **12.** (b) **13.** (c) **14.** (b)

Fill in the Blanks Type

15. 60 J **16.** 0.5×10^5 J **17.** Infinite
18. Remain same **19.** 3.6×10^3 cal **20.** negative
21. 8 atm **22.** 375 K **23.** more
24. –2 J

DPP 4.3

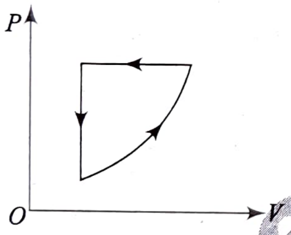
Application of First Law of Thermodynamics in Different Situations

Subjective Type

1. Two moles a monatomic gas in state 'A' having critical pressure P_0, and temperature $3T_0$ is taken to a state B having pressure $3P_0$ and temperature $T_0/3$ by the process of equation P^2T = constant. Then state B is taken to state C keeping volume constant and come back to initial state 'A' keeping temperature constant.
   (i) Plot a P and T graph. (P on y-axis and T on x-axis)
   (ii) Find net work done and heat supplied to gas during the complete cycle.

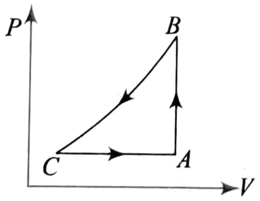
Single Correct Answer Type

2. For one complete cycle of a thermodynamic process on a gas as shown in the P-V diagram, which of following is correct



(a) $\Delta E_{int} = 0, Q < 0$ (b) $\Delta E_{int} = 0, Q > 0$
(c) $\Delta E_{int} > 0, Q < 0$ (d) $\Delta E_{int} < 0, Q > 0$

3. A sample of an ideal gas is taken through a cycle a shown in figure. It absorbs 50 J of energy during the process AB, no heat during BC, rejects 70 J during CA. 40 J of work is done on the gas during BC. Internal energy of gas at A is 1500 J, the internal energy at C would be

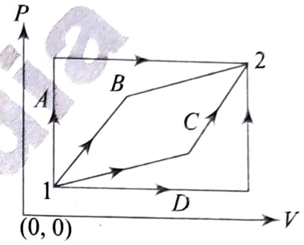


(a) 1590 J (b) 1620 J (c) 1540 J (d) 1570 J

4. A thermodynamic process of one mole ideal monoatomic gas is shown in figure. The efficiency of cyclic process $ABCA$ will be:

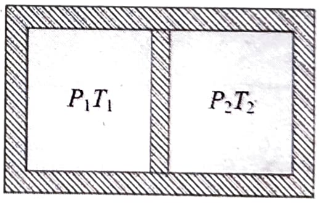
(a) 25% (b) 12.5% (c) 50% (d) $\frac{100}{13}$%

5. An ideal gas is taken from state 1 to state 2 through optional path A, B, C and D as shown in the PV diagram. Let Q, W and U represent the heat supplied, work done and change in internal energy of the gas respectively. Then



(a) $Q_A - Q_D = W_A - W_D$ (b) $Q_B - W_B > Q_C - W_C$
(c) $W_A < W_B < W_C < W_D$ (d) $Q_A < Q_B < Q_C < Q_D$

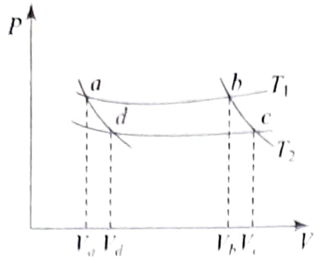
6. Following figure shows on adiabatic cylindrical container of volume V_0 divided by an adiabatic smooth piston (area of cross-section = A) in two equal parts. An ideal gas $\left(\frac{C_P}{C_V} = \gamma\right)$ is at pressure P_1 and temperature T_1 in left part and gas at pressure P_2 and temperature T_2 in right part. The piston is slowly displaced and released at a position where it can stay in equilibrium. The final pressure of the two parts will be (Suppose x = displacement of the piston)



(a) P_2 (b) P_1

(c) $\dfrac{P_1\left(\frac{V_0}{2}\right)^{\gamma}}{\left(\frac{V_0}{2}+Ax\right)^{\gamma}}$ (d) $\dfrac{P_2\left(\frac{V_0}{2}\right)^{\gamma}}{\left(\frac{V_0}{2}+Ax\right)^{\gamma}}$

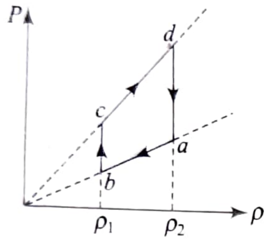
7. In the following P-V diagram two adiabatics cut two isothermals at temperatures T_1 and T_2 (fig.). The value of $\frac{V_a}{V_d}$ will be



(a) $\frac{V_b}{V_c}$ (b) $\frac{V_c}{V_b}$ (c) $\frac{V_d}{V_a}$ (d) V_bV_c

Multiple Correct Answers Type

8. An ideal gas undergoes a cyclic process *abcda* which is shown by pressure-density curve.

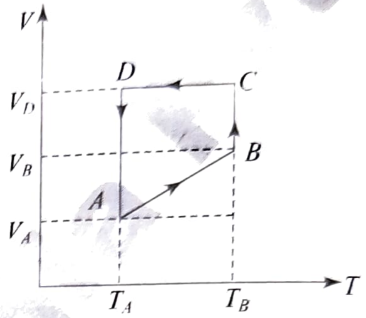


(a) Work done by the gas in the process '*bc*' is zero
(b) Work done by the gas in the process '*cd*' is negative
(c) Internal energy of the gas at point '*a*' is greater than at state '*c*'
(d) Net work done by the gas in the cycle is negative.

9. An ideal gas can be expanded from an initial state to a certain volume through two different processes: (i) PV^2 = constant and (ii) $P = KV^2$, where K is a positive constant. Then
(a) Final temperature in (i) will be greater than in (ii)
(b) Final temperature in (ii) will be greater than in (i)
(c) Total heat given to the gas in (i) case is greater than in (ii)
(d) Total heat given to the gas in (ii) case is greater than in (i)

Comprehension Type

A monoatomic ideal gas of two moles is taken through a cyclic process straining from A as shown $V_B/V_A = 2$ and $V_D/V_A = 4$. Temperature T_A at A is 27°C



10. The temperature at B, T_B is
(a) 600 K (b) 450 K (c) 400 K (d) 900 K

11. The work done during the process $A \rightarrow B$:
(a) 1200 R (b) 1500 R (c) 1400 R (d) 1000 R

12. The work done during process $B \rightarrow C$ (approx) is
(a) 1000 R (b) 800 R (c) 832 R (d) 945 R

13. The work done during the process $C \rightarrow D$ is
(a) 900 R (absorbed) (b) 900 R (released)
(c) 1200 R (absorbed) (d) 1200 R (released)

14. The work done during the process $D \rightarrow A$ is
(a) 900 R (absorbed) (b) 900 R (released)
(c) 832 R (absorbed) (d) 832 R (released)

15. The work done during the entire process is
(a) 400 R (b) 600 R (c) 450 R (d) 800 R

Answers Key

Single Correct Answer Type

2. (a) 3. (a) 4. (d) 5. (a)
6. (c) 7. (a)

Multiple Correct Answers Type

8. (a, b, d) 9. (b, d)

Comprehension Type

10. (a) 11. (b) 12. (c) 13. (b) 14. (d)
15. (b)

CHAPTER 5

Linear and Angular Simple Harmonic Motion

DPP 5.1

Equation of SHM, Phase and Comparing SHM with Uniform Circular Motion

Subjective Type

1. Describe the motion of a particle acted upon by the force:
(a) $F = 3x + 3$ (b) $F = -3x - 3$
(c) $F = -3x + 3$ (d) $F = 3x - 3$

Single Correct Answer Type

2. A body is moving in a room with a velocity of 20 m/s perpendicular to the two walls separated by 5 meters. There is no friction and the collisions with the walls are elastic. The motion of the body is
(a) Not periodic
(b) Periodic but not simple harmonic
(c) Periodic and simple harmonic
(d) Periodic with variable time period

3. The equation of motion of a particle is $x = a\cos(\alpha t)^2$. The motion is
(a) periodic but not oscillatory
(b) periodic and oscillatory
(c) oscillatory but not periodic
(d) neither periodic nor oscillatory

4. As the expression is involving sine function, which of the following equations does not represent a simple harmonic motion?
(a) $y = a\sin\omega t$
(b) $y = a\cos\omega t$
(c) $y = a\sin\omega t + b\cos\omega t$
(d) $y = a\tan\omega t$

5. The displacement of a particle is represented by the equation $y = \sin^3\omega t$. The motion is
(a) non-periodic
(b) periodic but not simple harmonic
(c) simple harmonic with period $2\pi/\omega$
(d) simple harmonic with period π/ω

6. Values of the acceleration A of a particle moving in simple harmonic motion as a function of its displacement x are given in the table below.

A (mm s^{-2})	16	8	0	−8	−16
x (mm)	−4	−2	0	2	4

The period of the motion is
(a) $\frac{1}{\pi}$ s (b) $\frac{2}{\pi}$ s (c) $\frac{\pi}{2}$ s (d) π s

7. The time taken by a particle performing SHM on a straight line to pass from point A to B where its velocities are same is 2 seconds. After another 2 seconds it returns to B. The time period of oscillation is (in seconds):
(a) 2 (b) 4 (c) 6 (d) 8

8. A particle is performing simple harmonic motion along x-axis with amplitude 4 cm and time period 1.2 sec. The minimum time taken by the particle to move from $x = 2$ cm to $x = +4$ cm and back again is given by
(a) 0.6 sec (b) 0.4 sec
(c) 0.3 sec (d) 0.2 sec

9. Two particles P and Q describe SHM of same amplitude a, same frequency f along the same straight line. The maximum distance between the two particles is $a\sqrt{2}$. The phase difference between the particle is

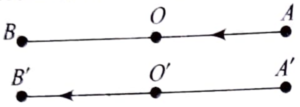
(a) zero (b) $\frac{\pi}{2}$ (c) $\frac{\pi}{6}$ (d) $\frac{\pi}{3}$

10. A particle executing SHM of amplitude 4 cm and $T = 4$ s. The time taken by it to move from positive extreme position to half the amplitude is

(a) 1 sec (b) 1/3 sec

(c) 2/3 sec (d) $\sqrt{3/2}$ sec

11. Two particles undergo SHM along parallel lines with the same time period (T) and equal amplitudes. At a particular instant, one particle is at its extreme position while the other is at its mean position. They move in the same direction. They will cross each other after a further time.



(a) $T/8$ (b) $3T/8$ (c) $T/6$ (d) $4T/3$

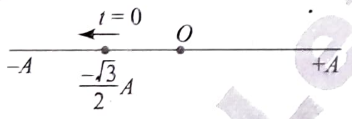
12. Two particles execute SHM of same amplitude of 20 cm with same period along the same line about the same equilibrium position. If the phase difference is $\pi/3$, then the maximum distance between these two will be

(a) 10 cm (b) 20 cm

(c) $10\sqrt{2}$ cm (d) $20\sqrt{2}$ cm

Multiple Correct Answers Type

13. A particle starts from point $x = \frac{-\sqrt{3}}{2}A$ and move towards negative extreme as shown. If the time period of oscillation is T, then



(a) The equation of the SHM is $x = A\sin\left(\frac{2\pi}{T} + \frac{4\pi}{3}\right)$

(b) The time taken by the particle to go directly from its initial position to negative extreme is $\frac{T}{12}$

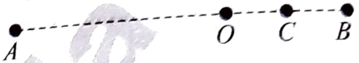
(c) The time taken by the particle to reach at mean position is $\frac{T}{3}$

(d) The equation of the SHM is $x = A\sin\left(\frac{2\pi}{T} + \frac{\pi}{3}\right)$

14. A particle is in linear simple harmonic motion between two points. A and B, 10 cm apart (**figure**), take the direction from A to B as the positive direction. Choose the correct statement(s).

$AO = OB = 5$ cm

$BC = 8$ cm



(a) The sign of velocity, acceleration and force on the particle when it is 3 cm away from A going towards B are positive

(b) The sign of velocity of the particle at C going towards B is negative

(c) The sign of velocity, acceleration and force on the particle when it is 4 cm away from B going towards A are negative

(d) The sign of acceleration and force on the particle when it is at points B is negative

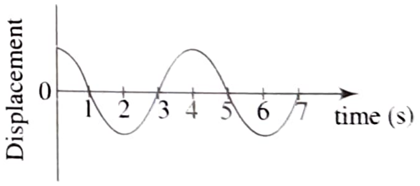
15. The displacement versus time curve for a particle executing SHM is shown in figure. Choose the correct statement(s).

(a) Phase of the oscillator is same at $t = 0$ s and $t = 2$ s.

(b) Phase of the oscillator is same at $t = 2$ s and $t = 6$ s.

(c) Phase of the oscillator is same at $t = 1$ s and $t = 7$ s.

(d) Phase of the oscillator is same at $t = 1$ s and $t = 5$ s.



Answers Key

Subjective Type

1. (a, d) Particle does not perform SHM
(b, c) Particle performs SHM

Single Correct Answer Type

2. (b) **3.** (c) **4.** (d) **5.** (b) **6.** (d) **7.** (d) **8.** (b) **9.** (b) **10.** (c) **11.** (b)
12. (a)

Multiple Correct Answers Type

13. (a, b, c) **14.** (a, c, d) **15.** (b, d)

DPP 5.2

Velocity, Acceleration and Energy of Simple Harmonic Motion

Subjective Type

1. The potential energy (U) of a body of unit mass moving in a one-dimension conservative force field is given by. $U = (x^2 - 4x + 3)$. All units are in S.I.
   (a) Find the equilibrium position of the body.
   (b) Show that oscillations of the body about this equilibrium position is simple harmonic motion and find its time period.
   (c) Find the amplitude of oscillations if speed of the body at equilibrium position is $2\sqrt{6}$ m/s.

Single Correct Answer Type

2. The maximum acceleration of a particle in SHM is made two times keeping the maximum speed to be constant. It is possible when
   (a) amplitude of oscillation is doubled while frequency remains constant
   (b) amplitude is doubled while frequency is halved
   (c) frequency is doubled while amplitude is halved
   (d) frequency is doubled while amplitude remains constant.

3. A particle in SHM is described by the displacement function $x(t) = a\cos(\omega t + \theta)$. If the initial ($t = 0$) position of the particle is 1 cm and its initial velocity is π cm/s. The angular frequency of the particle is π rad/s, then its amplitude is
   (a) 1 cm (b) $\sqrt{2}$ cm (c) 2 cm (d) 2.5 cm

4. Two particles P and Q describe simple harmonic motions of same period, same amplitude, along the same line about the same equilibrium position O. When P and Q are on opposite sides of O at the same distance from O, they have the same speed of 1.2 m/s in the same direction. When their displacements are the same, they have the same speed of 1.6 m/s in opposite directions. The maximum velocity in m/s of either particles is
   (a) 2.8 (b) 2.5 (c) 2.4 (d) 2

5. A particle executes simple harmonic motion with an amplitude of 4 cm. At the mean position, the velocity of the particle is 10 cm/s. The distance of the particle from the mean position when its speed becomes 5 cm/s is
   (a) $\sqrt{3}$ cm (b) $\sqrt{5}$ cm
   (c) $2(\sqrt{3})$cm (d) $2(\sqrt{5})$cm

6. A particle is executing SHM according to the equation $x = A\cos\omega t$. Average speed of the particle during the interval $0 \le t \le \frac{\pi}{6\omega}$.
   (a) $\frac{\sqrt{3}A\omega}{2}$ (b) $\frac{\sqrt{3}A\omega}{4}$
   (c) $\frac{3A\omega}{\pi}$ (d) $\frac{3A\omega}{\pi}(2-\sqrt{3})$

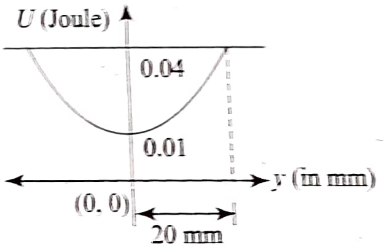
7. The total energy of the body executing S.H.M. is E. Then the kinetic energy when the displacement is half of the amplitude is
   (a) $\frac{E}{2}$ (b) $\frac{E}{4}$ (c) $\frac{3E}{4}$ (d) $\frac{\sqrt{3}}{4}E$

8. A body is executing Simple Harmonic Motion. At a displacement x its potential energy is E_1 and at a displacement y its potential energy is E_2. The potential energy E at displacement $(x + y)$ is
   (a) $\sqrt{E} = \sqrt{E_1} - \sqrt{E_2}$ (b) $\sqrt{E} = \sqrt{E_1} + \sqrt{E_2}$
   (c) $E = E_1 + E_2$ (d) $E = E_1 - E_2$

9. An object of mass 0.2 kg executes simple harmonic along X-axis with frequency of $\frac{25}{\pi}$ Hz. At the position $x = 0.04$ m, the object has kinetic energy of 0.5 J and potential energy of 0.4 J. The amplitude of oscillation in meter is equal to
   (a) 0.05 (b) 0.06
   (c) 0.01 (d) None of these

10. A particle of mass m is executing oscillations about the origin on the x-axis. Its potential energy is $U(x) = k|x|^3$, where k is a positive constant. If the amplitude of oscillation is a, then its time period T is
    (a) Proportional to $\frac{1}{\sqrt{a}}$ (b) Independent of a
    (c) Proportional to $\sqrt{a}$ (d) Proportional to $a^{3/2}$

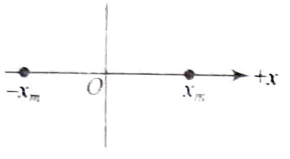
11. The variation of potential energy of harmonic oscillator is as shown in figure. The spring constant is



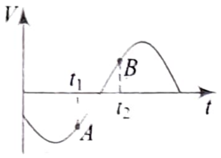
(a) 1×10^2 N/m (b) 150 N/m
(c) 0.667×10^2 N/m (d) 3×10^2 N/m

Multiple Correct Answers Type

12. A particle is executing SHM between points $-X_m$ and X_m, as shown in figure (i). The velocity $V(t)$ of the particle is partially graphed and shown in figure (ii). Two points A and B corresponding to time t_1 and time t_2 respectively are marked on the $V(t)$ curve.



(i)

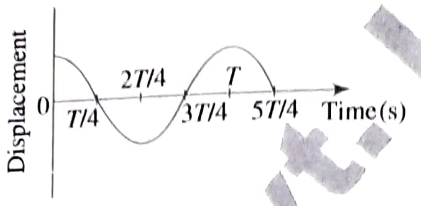


(ii)

(a) At time t_1, it is going towards X_m.
(b) At time t_1, its speed is decreasing.
(c) At time t_2, its position lies in between $-X_m$ and O.
(d) The phase difference $\Delta\phi$ between points A and B must be expressed as $90° < \Delta\phi < 180°$.

13. Which of the following statements is/are true for a simple harmonic oscillator?
(a) Force acting is directly proportional to displacement from the mean position and opposite to it
(b) Motion is periodic
(c) Acceleration of the oscillator is constant
(d) The velocity is periodic

14. The displacement-time graph of a particle executing SHM is shown in figure. Which of the following statement is/are true?



(a) The force is zero at $t = \frac{3T}{4}$
(b) The acceleration is maximum at $t = \frac{4T}{4}$
(c) The velocity is maximum at $t = \frac{T}{4}$
(d) The PE is equal to KE of oscillation at $t = \frac{T}{2}$

15. A linear harmonic oscillator of force constant 2×10^6 N/m times and amplitude 0.01 m has a total mechanical energy of 160 joules. Its
(a) Maximum P.E. is 100 J.
(b) Maximum K.E. is 100 J.
(c) Maximum P.E. is 160 J.
(d) Minimum P.E. is zero.

Answers Key

Subjective Type

1. (a) $F = 2$ (b) $T = \sqrt{2}\pi$ (c) $A = 2\sqrt{3}$

Single Correct Answer Type

2. (c) **3.** (b) **4.** (d) **5.** (c) **6.** (d)
7. (c) **8.** (b) **9.** (b) **10.** (a) **11.** (b)

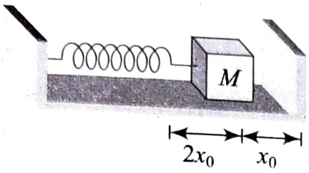
Multiple Correct Answers Type

12. (b, c) **13.** (a, b, d) **14.** (a, b, c)
15. (b, c)

DPP 5.3

Spring Particle System

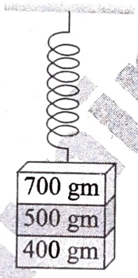
Single Correct Answer Type



1. One end of a spring of force constant k is fixed to a vertical wall and the other to a block of mass m resting on a smooth horizontal surface. There is another wall at a distance x_0 from the block. The spring is then compressed by $2x_0$ and released. The time taken to strike the wall is

(a) $\frac{1}{6}\pi\sqrt{\frac{k}{m}}$ (b) $\sqrt{\frac{k}{m}}$

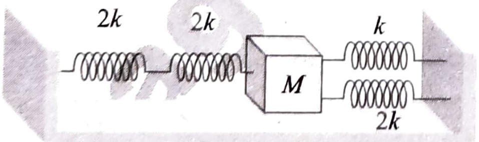
(c) $\frac{2\pi}{3}\sqrt{\frac{m}{k}}$ (d) $\frac{\pi}{4}\sqrt{\frac{k}{m}}$



2. Three masses 700 g, 500 g, and 400 g are suspended at the end of a spring a shown and are in equilibrium. When the 700 g mass is removed, the system oscillates with a period of 3 seconds, when the 500 gm mass is also removed, it will oscillate with a period of

(a) 1 s (b) 2 s (c) 3 s (d) $\sqrt{\frac{12}{5}}$ s

3. Four massless springs whose force constants are $2k$, $2k$, k and $2k$, respectively, are attached to a mass M kept on a frictionless plane (as shown in figure). If the mass M is displaced in the horizontal direction, then the frequency of oscillation of the system is



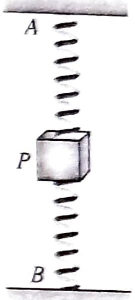
(a) $\frac{1}{2\pi}\sqrt{\frac{k}{4M}}$ (b) $\frac{1}{2\pi}\sqrt{\frac{4k}{M}}$

(c) $\frac{1}{2\pi}\sqrt{\frac{k}{7M}}$ (d) $\frac{1}{2\pi}\sqrt{\frac{7k}{M}}$

4. A body at the end of a spring executes SHM with a period t_1, while the corresponding period for another spring is t_2. If the period of oscillation with the two spring in series is T, then

(a) $T = t_1 + t_2$ (b) $T^2 = t_1^2 + t_2^2$

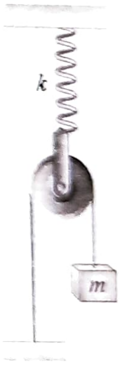
(c) $\frac{1}{T} = \frac{1}{t_1} + \frac{1}{t_2}$ (d) $\frac{1}{T^2} = \frac{1}{t_1^2} + \frac{1}{t_2^2}$



5. Two identical springs are attached to a small block P. The other ends of the springs are fixed at A and B. When P is in equilibrium the extension of top spring is 20 cm and extension of bottom spring is 10 cm. The period of small vertical oscillations of P about its equilibrium position is (use g = 9.8 m/s^2)

(a) $\frac{2\pi}{7}$ sec (b) $\frac{\pi}{7}$ sec

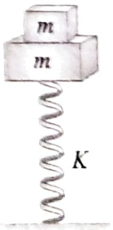
(c) $\frac{2\pi}{5}$ sec (d) none of these



6. Figure shows a system consisting of a massless pulley, a spring of force constant k and a block of mass m. If the block is slightly displaced vertically down from its equilibrium position and then released, the period of its vertical oscillation is

(a) $2\pi\sqrt{\frac{m}{K}}$ (b) $\pi\sqrt{\frac{m}{4K}}$

(c) $\pi\sqrt{\frac{m}{K}}$ (d) $4\pi\sqrt{\frac{m}{K}}$



7. A block of mass m is at rest on the another block of same mass as shown in figure. Lower block is attached to the spring then the maximum amplitude of motion so that both the block will remain in contact is

(a) $\frac{mg}{2k}$ (b) $\frac{mg}{k}$

(c) $\frac{2mg}{k}$ (d) $\frac{3mg}{2k}$

Multiple Correct Answers Type

8. The springs shown in the figure are all upstretched in the beginning when a man starts pulling the block. The man exerts a constant force F on the block.

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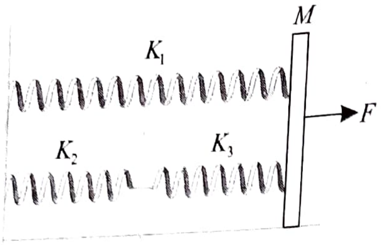


(a) the amplitude of oscillation is $\dfrac{(K_2+K_3)F}{K_1K_2+K_2K_3+K_3K_1}$

(b) the oscillation frequency is

$$\frac{1}{2\pi}\left[\frac{K_1K_2+K_2K_3+K_3K_1}{M(K_2+K_3)}\right]^{1/2}$$

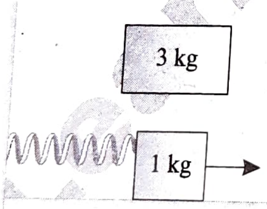
(c) the amplitude of oscillation is $\dfrac{2(K_2+K_3)F}{K_1K_2+K_2K_3+K_3K_1}$

(d) the oscillation frequency is

$$\frac{1}{\pi}\left[\frac{K_1K_2+K_2K_3+K_3K_1}{M(K_2+K_3)}\right]^{1/2}$$

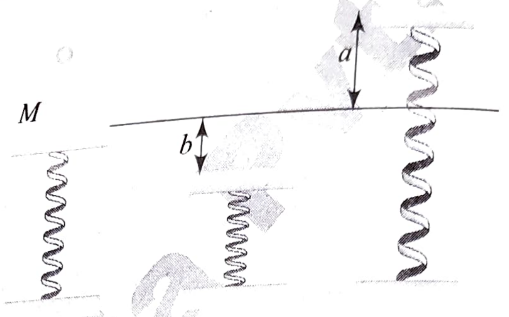
9. A spring has natural length 40 cm and spring constant 500 N/m. A block of mass 1 kg is attached at one end of the spring and other end of the spring is attached to ceiling. The block released from the position, where the spring has length 45 cm.
(a) the block will perform SHM of amplitude 5 cm.
(b) the block will have maximum velocity $30\sqrt{5}$ cm/sec.
(c) the block will have maximum acceleration 15 m/s^2.
(d) the minimum potential energy of the spring will be zero.

10. A 1-kg block is executing simple harmonic motion of amplitude 0.1 m on a smooth horizontal surface under the restoring force of a spring of spring constant 100 N/m. A block of mass 3 kg is gently placed on it at the instant it passes through the mean position. Assuming that the two blocks move together,



(a) amplitude of the motion is 5 cm
(b) the oscillation frequency is $\dfrac{5}{2\pi}$ Hz
(c) amplitude of the motion is 10 cm
(d) the oscillation frequency is $\dfrac{5}{\pi}$ Hz

11. A mass M is in static equilibrium on a massless vertical spring as shown in the figure. A ball of mass m dropped from certain height sticks to the mass M after colliding with it. The oscillations they perform reach to height 'a' above the original level of scales and depth 'b' below it.



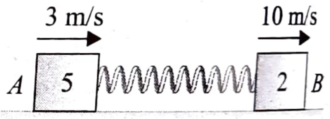
(a) the force constant of the spring is $\dfrac{2mg}{b-a}$

(b) the oscillation frequency is $\dfrac{1}{2\pi}\sqrt{\dfrac{2mg}{(b-a)(M+m)}}$

(c) the force constant of the spring is $\dfrac{mg}{b-a}$

(d) the oscillation frequency is $\dfrac{1}{2\pi}\sqrt{\dfrac{mg}{(b-a)(M+m)}}$

12. Two blocks A (5 kg) and B (2 kg) attached to the ends of a spring constant 1120 N/m are placed on a smooth horizontal plane with the spring unreformed. Simultaneously velocities of 3 m/s and 10 m/s along the line of the spring in the same direction are imparted to A and B then



(a) the maximum extension of the spring is 0.25 m
(b) the first maximum compression occurs after start at $\dfrac{3\pi}{56}$ s
(c) the maximum extension of the spring is 0.50 m
(d) Time period of oscillation is $\dfrac{\pi}{14}$ s

Answers Key

Single Correct Answer Type

1. (c) **2.** (b) **3.** (b) **4.** (b) **5.** (b)
6. (d) **7.** (c)

Multiple Correct Answers Type

8. (a, b) **9.** (b, c, d) **10.** (a, b) **11.** (a, b)
12. (b, d)

DPP 5.4

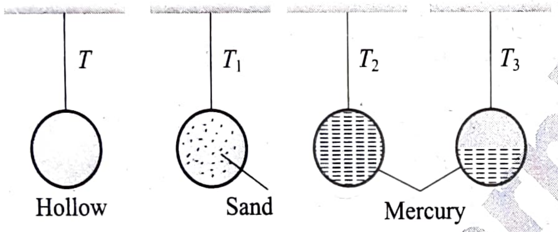
Simple Pendulum and Different Cases of SHM

Subjective Type

1. Consider a pair of identical pendulums, which oscillate with equal amplitude independently such that when one pendulum is at its extreme position making an angle of 2° to the right with the vertical, the other pendulum makes an angle of 1° to the left of the vertical. What is the phase difference between the pendulums?

Single Correct Answer Type

2. The period of a simple pendulum, whose bob is a hollow metallic sphere is T. The period is T_1 when the bob is filled with sand, T_2 when it is filled with mercury and T_3 when it is half-filled with mercury. Which of the following is true?



(a) $T = T_1 = T_2 > T_3$ (b) $T_1 = T_1 = T_3 > T$
(c) $T > T_3 > T_1 = T_2$ (d) $T = T_1 = T_2 < T_3$

3. A pendulum has time period T in air. When it is made to oscillate in water, it acquired a time period $T' = \sqrt{2}T$. The density of the pendulum bob is equal to (density of water = 1)

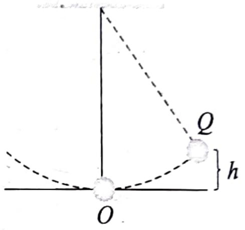
(a) $\sqrt{2}$ (b) 2
(c) $2\sqrt{2}$ (d) None of these

4. A sphere of radius r is kept on a concave mirror of radius of curvature R. The arrangement is kept on a horizontal table (the surface of concave mirror is frictionless and sliding not rolling). If the sphere is displaced from its equilibrium position and left, then it executes S.H.M. The period of oscillation will be

(a) $2\pi\sqrt{\left(\frac{(R-r)1.4}{g}\right)}$ (b) $2\pi\sqrt{\left(\frac{R-r}{g}\right)}$
(c) $2\pi\sqrt{\left(\frac{rR}{a}\right)}$ (d) $2\pi\sqrt{\left(\frac{R}{gr}\right)}$

5. Two simple pendulums of length 5 m and 20 m respectively are given small linear displacement in one direction at the same time. They will again be in the phase when the pendulum of shorter length has completed .... oscillations.
(a) 5 (b) 1 (c) 2 (d) 3

6. The bob of a simple pendulum is displaced from its equilibrium position O to a position Q which is at height h above O and the bob is then released. Assuming the mass of the bob to be m and time period of oscillations to be 2 s, the tension in the string when the bob passes through O is



(a) $m(g+\pi\sqrt{2gh})$ (b) $m(g+\sqrt{\pi^2 gh})$
(c) $m\left(g+\sqrt{\frac{\pi^2}{2}gh}\right)$ (d) $m\left(g+\sqrt{\frac{\pi^2}{3}gh}\right)$

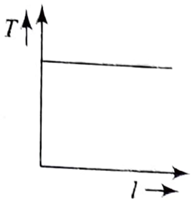
7. Two simple pendulums whose lengths are 100 cm and 121 cm are suspended side by side. Their bobs are pulled together and then released. After how many minimum oscillations of the longer pendulum, will the two be in phase again
(a) 11 (b) 10 (c) 21 (d) 20

8. Two pendulums have time periods T and $\frac{5T}{4}$. They start S.H.M. at the same time from the mean position. What will be the phase difference between them after the bigger pendulum has complete one oscillation
(a) 45° (b) 90° (c) 60° (d) 30°

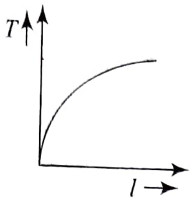
9. Two simple pendulum first of bob mass M_1 and length L_1 second of bob mass M_2 and length L_2. $M_1 = M_2$ and $L_1 = 2L_2$. If these vibrational energy of both is same. Then which is correct
(a) Amplitude of B greater than A
(b) Amplitude of B smaller than A
(c) Amplitudes will be same
(d) None of these

10. In case of a simple pendulum, time period versus length is depicted by

(a)



(b)



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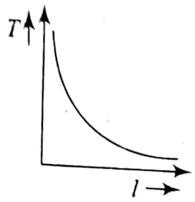
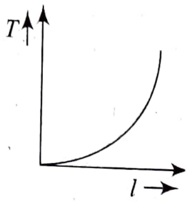


(d)



11. A U tube of uniform bore of cross-sectional area A has been set up vertically with open ends facing up. Now m gm of a liquid of density d is poured into it. The column of liquid in this tube will oscillate with a period T such that

(a) $T=2\pi\sqrt{\dfrac{M}{g}}$ (b) $T=2\pi\sqrt{\dfrac{MA}{gd}}$

(c) $T=2\pi\sqrt{\dfrac{M}{gdA}}$ (d) $T=2\pi\sqrt{\dfrac{M}{2Adg}}$

12. A horizontal platform with an object placed on it is executing S.H.M. in the vertical direction. The amplitude of oscillation is 3.92×10^{-3} m. What must be the least period of these oscillations, so that the object is not detached from the platform

(a) 0.1256 sec (b) 0.1356 sec

(c) 0.1456 sec (d) 0.1556 sec

13. The metallic bob of a simple pendulum has the relative density ρ. The time period of this pendulum is T. If the metallic bob is immersed in water, then the new time period is given by

(a) $T\dfrac{\rho-1}{\rho}$ (b) $T\dfrac{\rho}{\rho-1}$

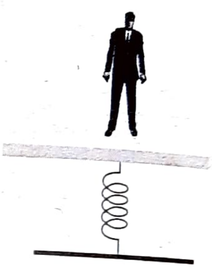
(c) $T\sqrt{\dfrac{\rho-1}{\rho}}$ (d) $T\sqrt{\dfrac{\rho}{\rho-1}}$

14. A brass cube of side a and density σ is floating in mercury of density ρ. If the cube is displaced a bit vertically, it executes S.H.M. Its time period will be

(a) $2\pi\sqrt{\dfrac{\sigma a}{\rho g}}$ (b) $2\pi\sqrt{\dfrac{\rho a}{\sigma g}}$

(c) $2\pi\sqrt{\dfrac{\rho g}{\sigma a}}$ (d) $2\pi\sqrt{\dfrac{\sigma g}{\rho a}}$

15. A man weighing 60 kg stands on the horizontal platform of a spring balance. The platform starts executing simple harmonic motion of amplitude 0.1 m and frequency $\dfrac{2}{\pi}$ Hz. Which of the following statement is correct?



(a) The spring balance reads the weight of man as 60 kg

(b) The spring balance reading fluctuates between 60 kg. and 70 kg

(c) The spring balance reading fluctuates between 50 kg and 60 kg

(d) The spring balance reading fluctuates between 50 kg and 70 kg

Answers Key

Subjective Type

1. 120°

Single Correct Answer Type

2. (d) **3.** (b) **4.** (b) **5.** (c) **6.** (a)
7. (b) **8.** (b) **9.** (b) **10.** (b) **11.** (d)
12. (a) **13.** (d) **14.** (a) **15.** (d)

DPP 5.5

Superposition of SHM and Compound Pendulum

Subjective Type

1. A uniform square plate of side 'a' is hinged at one of its corners. It is suspended such that it can rotate about horizontal axis. Find out its time period of small oscillation about its equilibrium position. (You can use the formula of time period of compound pendulum if you know otherwise derive it)

2. A particle of mass 'm' is moving in the x-y plane such that its x and y coordinate vary according to the law $x = a \sin \omega t$ and $y = a \cos \omega t$ where 'a' and 'ω' are positive constants and 't' is time. Find

(a) equation of the path. Name the trajectory (path).

(b) whether the particle moves in clockwise or anticlockwise direction

(c) magnitude of the force on the particle at any time t.

Single Correct Answer Type

3. The displacement of a particle from its mean position (in metre) is given by

$$y = 0.2 \sin (10\pi t + 1.5\pi) \cos (10\pi t + 0.5\pi).$$

The motion of particle is

(a) Periodic but not S.H.M.

(b) Non-periodic

(c) Simple harmonic motion with period 0.1 s

(d) Simple harmonic motion with period 0.2 s

4. The displacement of a particle varies with time as $x = 12 \sin \omega t - 16 \sin^3 \omega t$ (in cm). If its motion is S.H.M., then its maximum acceleration is

(a) $12\omega^2$ (b) $36\omega^2$

(c) $144\omega^2$ (d) $\sqrt{192}\,\omega^2$

5. A particle is acted simultaneously by mutually perpendicular simple harmonic motion $x = a \cos \omega t$ and $y = a \sin \omega t$. The trajectory of motion of the particle will be

(a) an ellipse (b) a parabola

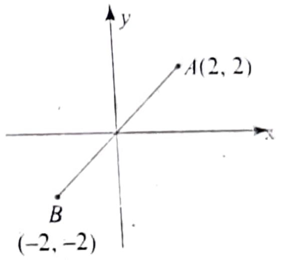
(c) a circle (d) a straight line

6. A disc of radius R and mass M is pivoted at the rim and is set for small oscillations. If simple pendulum has to have the same period as that of the disc, the length of the simple pendulum should be

(a) $\frac{5}{4}R$ (b) $\frac{2}{3}R$

(c) $\frac{3}{4}R$ (d) $\frac{3}{2}R$

7. A particle of mass m = 2 kg executes SHM in xy-plane between points A and B under action of force $\vec{F} = F_x\hat{i} + F_y\hat{j}$. Minimum time taken by particle to move from A to B is 1 sec. At t = 0, the particle is at x = 2 and y = 2. Then F_x as function of time t is



(a) $-4\pi^2 \sin \pi t$ (b) $-4\pi^2 \cos \pi t$

(C) $4\pi^2 \cos \pi t$ (d) None of these

Multiple Correct Answers Type

8. The displacement of a particle varies with time according to the relation

$y = a \sin \omega t + b \cos \omega t$

(a) The motion is SHM

(b) The motion is SHM with amplitude $a + b$

(c) The motion is SHM with amplitude $a^2 + b^2$

(d) The motion is SHM with amplitude $\sqrt{a^2 + b^2}$

9. Three simple harmonic motions in the same direction having the same amplitude and same period are superimposed. If each differ in phase from the next by 45°, then:

(a) the resultant amplitude is $(1+\sqrt{2})a$.

(b) the phase of the resultant motion relative to first is 90°.

(c) The energy associated with the resultant motion is $(3+2\sqrt{2})$ times the energy associated with any single motion.

(d) the resulting motion is not simple harmonic.

10. Function $x = A \sin^2 \omega t + B \cos^2 \omega t + C \sin \omega t \cos \omega t$ Represents SHM.

(a) For any value of A, B and C (except $C = 0$).

(b) If $A = -B$, $C = 2B$ and amplitude = $|B\sqrt{2}|$

(c) If $A = B$, $C = 0$

(d) If $A = B$, $C = 2B$ amplitude = $|B|$.

11. The position of a particle w.r.t. to origin varies according to the relation $x = 3 \sin 100t + 8 \cos^2 50t$. Which of the following is/are correct about this motion?

(a) the motion of the particle is not S.H.M.

(b) the amplitude of the S.H.M. of the particle is 5 units

(c) the amplitude of the resultant S.H. M. is $\sqrt{73}$ units

(d) the maximum displacement of the particle from the origin is 9 units.

Answers Key

Subjective Type

1. $2\pi\sqrt{\frac{2\sqrt{2a}}{3g}}$

2. (a) $x^2 + y^2 = a^2$ (circle)

(b) Clockwise

(c) $m\omega^2 a$

Single Correct Answer Type

3. (c) **4.** (b) **5.** (c) **6.** (d) **7.** (b)

Multiple Correct Answers Type

8. (a, d) **9.** (a, c) **10.** (b, d) **11.** (b, d)

CHAPTER

6

Travelling Waves

DPP 6.1

Travelling Waves

Single Correct Answer Type

1. Which of the following function correctly represent the travelling wave equation for finite values of x and t?
   (a) $y = x^2 - t^2$
   (b) $y = \cos x^2 \sin t$
   (c) $y = \log (x^2 - t^2) - \log (x - t)$
   (d) $y = e^{2x} \sin t$

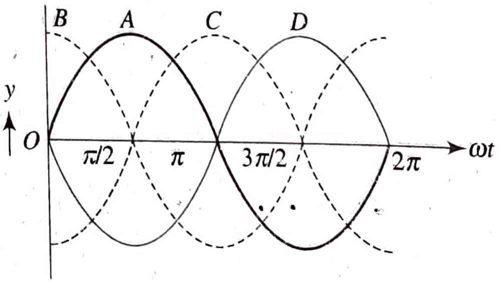
2. At $t = 0$, a transverse wave pulse travelling in the positive x direction with a speed of 2 m/s in a wire is described by the function $y = \dfrac{6}{x^2}$, given that $x \neq 0$. Transverse velocity of a particle at $x = 2$ m and $t = 2$ seconds is:
   (a) 3 m/s (b) −3 m/s (c) 8 m/s (d) −8 m/s

3. A wave travelling in positive X-direction with $A = 0.2$ m has a velocity of 360 m/sec. If $\lambda = 60$ m, then correct expression for the wave is
   (a) $y = 0.2 \sin\left[2\pi\left(6t + \dfrac{x}{60}\right)\right]$
   (b) $y = 0.2 \sin\left[\pi\left(6t + \dfrac{x}{60}\right)\right]$
   (c) $y = 0.2 \sin\left[2\pi\left(6t - \dfrac{x}{60}\right)\right]$
   (d) $y = 0.2 \sin\left[\pi\left(6t - \dfrac{x}{60}\right)\right]$

4. The equation $y = A\cos^2\left(2\pi nt - 2\pi\dfrac{x}{\lambda}\right)$ represents a wave with
   (a) Amplitude $A/2$, frequency $2n$ and wavelength $\lambda/2$
   (b) Amplitude $A/2$, frequency $2n$ and wavelength λ
   (c) Amplitude A, frequency $2n$ and wavelength 2λ
   (d) Amplitude A, frequency n and wavelength λ

5. The path difference between the two waves
   $y_1 = a_1 \sin\left(\omega t - \dfrac{2\pi x}{\lambda}\right)$ and $y_2 = a_2 \cos\left(\omega t - \dfrac{2\pi x}{\lambda} + \phi\right)$ is
   (a) $\dfrac{\lambda}{2\pi}\phi$ (b) $\dfrac{\lambda}{2\pi}\left(\phi + \dfrac{\pi}{2}\right)$
   (c) $\dfrac{2\pi}{\lambda}\left(\phi - \dfrac{\pi}{2}\right)$ (d) $\dfrac{2\pi}{\lambda}\phi$

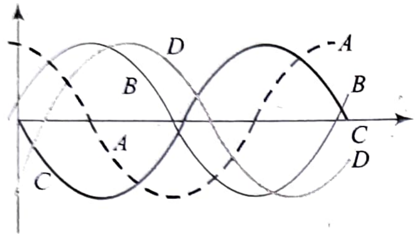
6. The figure shows four progressive waves A, B, C, and D with their phases expressed with respect to the wave A. It can be concluded from the figure that



   (a) The wave C is ahead by a phase angle of $\pi/2$ and the wave B lags behind by a phase angle of $\pi/2$

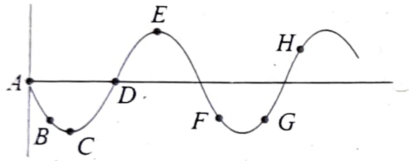
(b) The wave C lags behind by a phase angle of $\pi/2$ and the wave B is ahead by a phase angle of $\pi/2$
(c) The wave C is ahead by a phase angle of π and the wave B lags behind by a phase angle of π
(d) The wave C lags behind by a phase angle of π and the wave B ahead by a phase angle of π

7. Which of the following curves represents correctly the oscillation given by $y = y_0 \sin(\omega t - \phi)$, where $0 < \phi < 90$



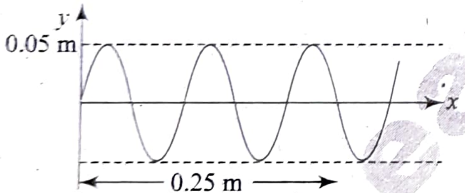
(a) A (b) B (c) C (d) D

8. The diagram below shows the propagation of a wave. Which points are in same phase



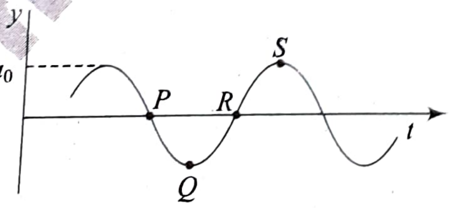
(a) F, G (b) C and E (c) B and G (d) B and F

9. If the speed of the wave shown in the figure is 330 m/s in the given medium, then the equation of the wave propagating in the positive x-direction will be (all quantities are in M.K.S. units)



(a) $y = 0.05 \sin 2\pi(4000t - 12.5x)$
(b) $y = 0.05 \sin 2\pi(4000t - 122.5x)$
(c) $y = 0.05 \sin 2\pi(3300t - 10x)$
(d) $y = 0.05 \sin 2\pi(3300t - 10t)$

A wave motion has the function $y = a_0 \sin(\omega t = kx)$. The graph in figure shows how the displacement y at a fixed point varies with time t. Which one of the labelled points shows a displacement equal to that at the position $x = \frac{\pi}{2k}$ at time $t = 0$

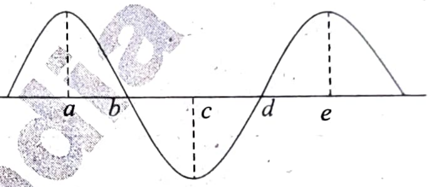


a) P (b) Q (c) R (d) S

Multiple Correct Answers Type

11. A wave equation which gives the displacement along the Y direction is given by the equation $y = 104 \sin(60t + 2x)$, where x and y are in metres and t is time in seconds. This represents a wave
(a) Travelling with a velocity of 30 m/sec in the negative X direction
(b) Of wavelength π metre
(c) Of frequency $30/\pi$ Hz
(d) Of amplitude 10^4 metre travelling along the negative X direction

12. The rope shown at an instant is carrying a wave travelling towards right, created by a source vibrating at a frequency n. Consider the following statements



(a) The speed of the wave is $4n \times ab$
(b) The medium at a will be in the same phase as d after $\frac{4}{3n}s$
(c) The phase difference between b and e is $\frac{3\pi}{2}$
(d) The speed of the wave is $2n \times ab$

Comprehension Type

$$y_1 = 2 \sin 3\pi t$$

$$y_2 = 2 \sin\left(3\pi t - \frac{\pi}{8}\right)$$

13. The wave velocity is
(a) 16 cm/sec (b) 24 cm/sec
(c) 12 cm/sec (d) 8 cm/sec

14. In the above question, the displacement of particle at $t = 1$ sec and $x = 4$ cm is
(a) 4 cm (b) 2 cm (c) 1 cm (d) zero

Fill in the Blanks Type

15. The equation of a wave is $y = 2 \sin \pi(0.5x - 200t)$, where x and y are expressed in cm and t in sec. The wave velocity is.................

16. Equation of a progressive wave is given by

$$y = 0.2 \cos \pi\left(0.04t + 0.02x - \frac{\pi}{6}\right)$$

The distance is expressed in cm and time in second. The minimum distance between two particles having the phase difference of $\pi/2$ is............

17. At a moment in a progressive wave, the phase of a particle executing S.H.M. is $\pi/3$. If the wavelength is 60 cm, then the phase of the particle 15 cm ahead and at the time $T/2$ will be.........

18. The equation of a wave travelling on a string is $y = 4\sin\frac{\pi}{2}\left(8t - \frac{x}{8}\right)$. If x and y are in cm, then velocity of wave is ....

19. A plane wave is represented by

$$x = 1.2\sin(314t + 12.56y)$$

where x and y are distances measured along in x and y direction in meters and t is time in seconds. This wave has ....

20. The phase difference between two waves represented by

$$y_1 = 10^{-6}\cos[100t + (x/50) + 0.5]m$$
$$y_2 = 10^{-6}\sin[100t + (x/50) + 0.5]m$$

where x is expressed in metres and t is expressed in seconds, is approximately ....

Answers Key

Single Correct Answer Type

1. (c) **2.** (b) **3.** (c) **4.** (a) **5.** (b)
6. (b) **7.** (d) **8.** (d) **9.** (c) **10.** (b)

Multiple Correct Answers Type

11. (a, b, c, d) **12.** (a, c)

Comprehension Type

13. (b) **14.** (b)

Fill in the Blanks Type

15. 400 cm/sec **16.** 25 cm **17.** $\frac{5\pi}{6}$
18. 64 cm/sec in + x direction
19. A wavelength of 0.5 m and travels in –ve y direction
20. 1.07 rad

DPP 6.2

Equation and Energy of Progressive Wave

Subjective Type

1. The equation of a travelling wave in a uniform string of mass per unit length μ is given as $y = A \sin(\omega t - kx)$. Find the total energy transferred through the origin in time interval from $t = 0$ to $t = \pi/12\omega$. [You can use the formula of instantaneous power if you know]

Single Answer Correct Type

2. A transverse wave is propagating along +x direction. At $t = 2$ sec, the particle at $x = 4$ m is at $y = 2$ mm. With the passage of time, its y coordinate increases and reaches to a maximum of 4 mm. The wave equation is (using ω and k with their usual meanings)

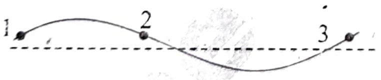
(a) $y = 4\sin\left[\omega(t+2) + k(x-2) + \dfrac{\pi}{6}\right]$

(b) $y = 4\sin\left[\omega(t+2) + k(x) + \dfrac{\pi}{6}\right]$

(c) $y = 4\sin\left[\omega(t-2) - k(x-4) + \dfrac{5\pi}{6}\right]$

(d) $y = 4\sin\left[\omega(t-2) - k(x-4) + \dfrac{\pi}{6}\right]$

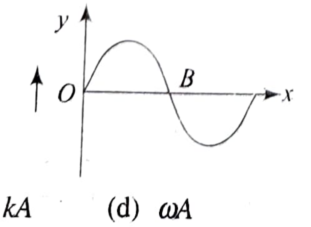
3. The diagram below shows an instantaneous position of a string as a transverse progressive wave travels along it from left to right



Which one of the following correctly shows the direction of the velocity of the points 1, 2 and 3 on the string

	1	2	3
(a)	→	→	→
(b)	→	←	→
(c)	↓	↓	↓
(d)	↓	↑	↓

4. Fig. below shows the wave $y = A \sin(\omega t - kx)$ at any instant travelling in the +ve x-direction. What is the slope of the curve at B



(a) ω/A (b) k/A (c) kA (d) ωA

5. The equation of a transverse wave travelling on a rope is given by $y = 10 \sin \pi(0.01x - 2.00t)$ where y and x are in cm and t in seconds. The maximum transverse speed of a particle in the rope is about

(a) 63 cm/s (b) 75 cm/s
(c) 100 cm/s (d) 121 cm/s

6. A transverse wave is represented by the equation

$$y = y_0 \sin\frac{2\pi}{\lambda}(vt - x)$$

For what value of λ, the maximum particle velocity equal to two times the wave velocity

(a) $\lambda = 2\pi y_0$ (b) $\lambda = \pi y_0/3$
(c) $\lambda = \pi y_0/2$ (d) $\lambda = \pi y_0$

7. A loop of a string of mass per unit length μ and radius R is rotated about an axis passing through centre perpendicular to the plane with an angular velocity ω. A small disturbance is created in the loop having the same sense of rotation. The linear speed of the disturbance for a stationary observer is

(a) ωR (b) $2\omega R$ (c) $3\omega R$ (d) zero

8. A transverse periodic wave on a string with a linear mass density of 0.200 kg/m is described by the following equation: $y = 0.05 \sin(420t - 21.0x)$ where x and y are in metres and t is in seconds. The tension in the string is equal to

(a) 32 N (b) 42 N (c) 66 N (d) 80 N

9. The displacement from the position of equilibrium of a point 4 cm from a source of sinusoidal oscillations is half the amplitude at the moment $t = T/6$ (T is the time period). Assume that the source was at mean position at $t = 0$. The wavelength of the running wave is

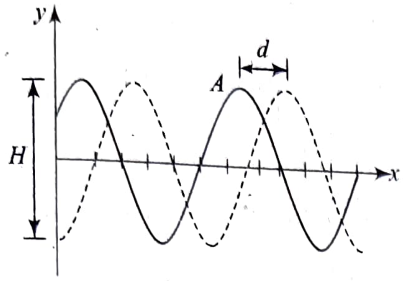
(a) 0.96 m (b) 0.48 m (c) 0.24 m (d) 0.12 m

10. A wave moving with constant speed on a uniform string passes the point $x = 0$ with amplitude A_0, angular frequency ω_0 and average rate of energy transfer P_0. As the wave travels down the string, it gradually loses energy and at the point $x = l$, the average rate of energy transfer becomes. At the point $x = l$, angular frequency and amplitude are, respectively

(a) ω_0 and $\dfrac{A_0}{\sqrt{2}}$ (b) $\dfrac{\omega_0}{\sqrt{2}}$ and A_0

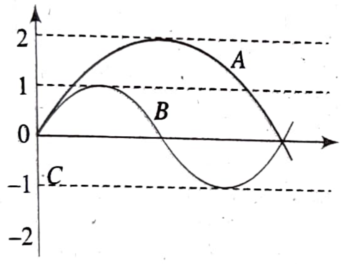
(c) less than ω_0 and A_0 (d) $\dfrac{\omega_0}{\sqrt{2}}$ and $\dfrac{A_0}{\sqrt{2}}$

11. A sinusoidal wave moving along a string is shown twice in Fig., as crest A travels in the positive direction of an x axis by distance $d = 6.0$ cm in 4.0 ms. The tick marks along the axis are separated by 10 cm; height $H = 6.00$ mm. The wave equation is



(a) $y = (3\text{ mm}) \sin [16x - 2.4 \times 10^2 t]$
(b) $y = (3\text{ mm}) \sin [16x + 2.4 \times 10^2 t]$
(c) $y = (3\text{ mm}) \sin [8x + 2.4 \times 10^2 t]$
(d) $y = (3\text{ mm}) \sin [8x - 2.4 \times 10^2 t]$

12. The displacement-time graphs for two sound waves A and B are shown in the figure, then the ratio of their intensities I_A/I_B is equal to

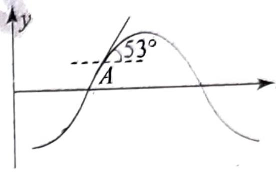


(a) 1 : 4
(b) 1 : 16
(c) 1 : 2
(d) 1 : 1

Multiple Correct Answers Type

13. As a wave propagates,
(a) the wave intensity remains constant for a plane wave
(b) the wave intensity decreases as the inverse of the distance from the source for a spherical wave
(c) the wave intensity decreases as the inverse square of the distance from the source for a spherical wave
(d) total intensity of the spherical wave over the spherical surface centered at the source remains constant at all times

14. The y-x curve at an instant for a wave travelling along x axis on a string is shown. Slope at the point A on the curve, as shown, is 53°. Which of the following is/are correct?



(a) Transverse velocity of the particle at point A is positive if the wave is travelling along positive x axis.
(b) Transverse velocity of the particle at point A is positive if the wave is travelling along negative x axis of the particle at point A.
(c) Magnitude of transverse velocity of the particle at point A is greater than wave speed.
(d) Magnitude of transverse velocity of the particle at point A is lesser than wave speed.

15. A sinusoidal wave is traveling on a string with speed 40 cm/s. The displacement of the particles of the string at $x = 10$ cm varies with time according to $y = (5.0\text{ cm}) \sin [1.0 - 4.0 s^{-1})t]$. The linear density of the string is 4.0 g/cm.
(a) the frequency of wave is 0.64 Hz.
(b) the wavelength of the wave 63 cm.
(c) the tension in the string 0.064 N
(d) the wave equation is $y = (5.0\text{ cm}) \sin [0.1x - (4.0 s^{-1})t]$

Answers Key

Subjective Type

1. $\dfrac{(\pi + 3)}{24} \dfrac{\mu \omega^2 A^2}{K}$

Single Correct Answer Type

2. (d) **3.** (d) **4.** (c) **5.** (a) **6.** (d)
7. (b) **8.** (d) **9.** (b) **10.** (a) **11.** (a)
12. (d)

Multiple Correct Answers Type

13. (a, c, d) **14.** (b, c) **15.** (a, b, c, d)

CHAPTER

7

Superposition and Standing Waves

DPP 7.1

Superposition and Interference

Single Correct Answer Type

1. Two sources of sound A and B produces the wave of 350 Hz, they vibrate in the same phase. The particle P is vibrating under the influence of these two waves, if the amplitudes at the point P produced by the two waves is 0.3 mm and 0.4 mm, then the resultant amplitude of the point P will be when $AP - BP = 25$ cm and the velocity of sound is 350 m/sec
   (a) 0.7 mm (b) 0.1 mm (c) 0.2 mm (d) 0.5 mm

2. Two waves are propagating to the point P along a straight line produced by two sources A and B of simple harmonic and of equal frequency. The amplitude of every wave at P is 'a' and the phase of A is ahead by $\frac{\pi}{3}$ than that of B and the distance AP is greater than BP by 50 cm. Then the resultant amplitude at the point P will be if the wavelength is 1 meter
   (a) $2a$ (b) $a\sqrt{3}$ (c) $a\sqrt{2}$ (d) a

3. The minimum intensity of sound is zero at a point due to two sources of nearly equal frequencies, when
   (a) two sources are vibrating in the opposite phase
   (b) the amplitude of two sources are equal
   (c) at the point of observation, the amplitudes of two S.H.M. produced by two sources are equal and both the S.H.M. are along the same straight line
   (d) both the sources are in the same phase

4. Out of the given four waves (1), (2), (3) and (4)

$$y = a\sin(kx + \omega t) \qquad (1)$$
$$y = a\sin(\omega t + kx) \qquad (2)$$
$$y = a\cos(kx + \omega t) \qquad (3)$$
$$y = a\cos(\omega t - kx) \qquad (4)$$

   emitted by four different sources S_1, S_2, S_3 and S_4 respectively, interference phenomena would be observed in space under appropriate conditions when
   (a) source S_1 emits wave (1) and S_2 emits wave (2)
   (b) source S_3 emits wave (3) and S_4 emits wave (4)
   (c) source S_2 emits wave (2) and S_4 emits wave (4)
   (d) S_4 emits waves (4) and S_3 emits waves (3)

5. Equation of motion in the same direction is given by $y_1 = A\sin(\omega t - kx)$, $y_2 = A\sin(\omega t - kx - \theta)$. The amplitude of the medium particle will be
   (a) $2A\cos\frac{\theta}{2}$ (b) $2A\cos\theta$
   (c) $\sqrt{2}A\cos\frac{\theta}{2}$ (d) $1.2f$, 1.2λ

6. The amplitude of a wave represented by displacement equation $y = \frac{1}{\sqrt{a}}\sin\omega t \pm \frac{1}{\sqrt{b}}\cos\omega t$ will be
   (a) $\frac{a+b}{ab}$ (b) $\frac{\sqrt{a}+\sqrt{b}}{ab}$
   (c) $\frac{\sqrt{a}\pm\sqrt{b}}{ab}$ (d) $\sqrt{\frac{a+b}{ab}}$

7. Two waves having equations

$x_1 = a \sin(\omega t + \phi_1)$, $x_2 = a \sin(\omega t + \phi_2)$

If in the resultant wave the frequency and amplitude remain equal to those of superimposing waves. Then phase difference between them is

(a) $\frac{\pi}{6}$ (b) $\frac{2\pi}{3}$ (c) $\frac{\pi}{4}$ (d) $\frac{\pi}{3}$

8. A travelling wave $y = A \sin(kx - \omega t + \theta)$ passes from a heavier string to a lighter string. The reflected wave has amplitude 0.5 A. The junction of the strings is at $x = 0$. The equation of the reflected wave is:

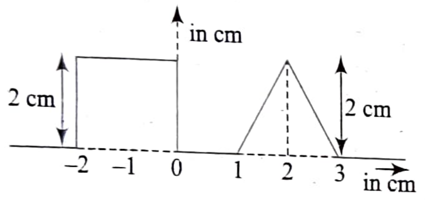
(a) $y' = 0.5A \sin(kx + \omega t + \theta)$

(b) $y' = -0.5A \sin(kx + \omega t + \theta)$

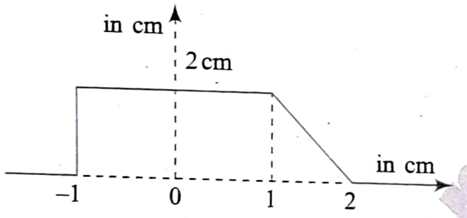
(c) $y' = -0.5A \sin(\omega t - kx - \theta)$

(d) $y' = -0.5A \sin(kx + \omega t - \theta)$

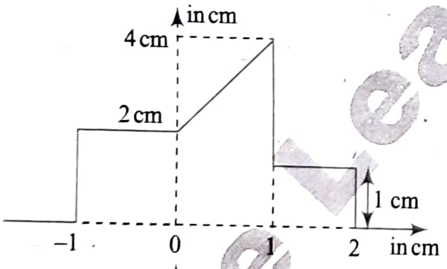
9. The figure shows at time $t = 0$ second, a rectangular and triangular pulse on a uniform wire are approaching each other. The pulse speed is 0.5 cm/s. The resultant pulse at $t = 2$ second is



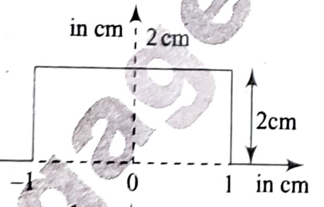
(a)



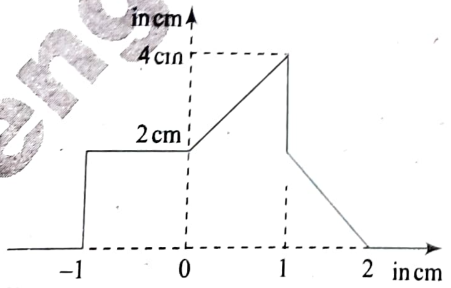
(b)



(c)



(d)



10. In a large room, a person receives direct sound waves from a source 120 metres away from him. He also receives waves from the same source which reach him, being reflected from the 25 metre high ceiling at a point halfway between them. The two waves interfere constructively for wavelength of

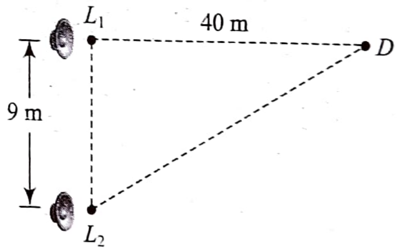
(a) 20, 20/3, 20/5, etc. (b) 10, 5, 2.5, etc.

(c) 10, 20, 30, etc. (d) 15, 25, 35, etc.

11. Two speakers connected to the same source of fixed frequency are placed 2.0 m apart in a box. A sensitive microphone placed at a distance of 4.0 m from their midpoint along the perpendicular bisector shows maximum response. The box is slowly rotated until the speakers are in line with the microphone. The distance between the midpoint of the speakers and the microphone remains unchanged. Exactly five maximum responses are observed in the microphone in doing this. The wavelength of the sound wave is

(a) 0.2 m (b) 0.4 m (c) 0.6 m (d) 0.8 m

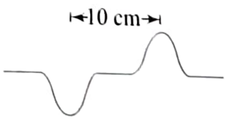
12. Two loudspeakers L_1 and L_2 driven by a common oscillator and amplifier are arranged as shown. The frequency of the oscillator is gradually increased from zero and the detector at D records a series of maxima and minima. If the speed of sound is 330 ms^{-1}, then the frequency at which the first maximum is observed is



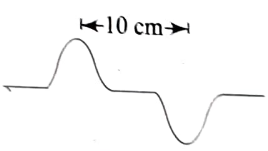
(a) 165 Hz (b) 330 Hz (c) 496 Hz (d) 660 Hz

13. Two pulses travel in mutually opposite directions in a string with a speed of 2.5 cm/s as shown in the figure. Initially the pulses are 10 cm apart. What will be the state of the string after two seconds?

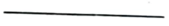
(a)



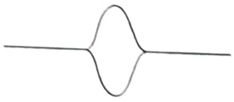
(b)



(c)



(d)



Multiple Correct Answers Type

14. Two wave functions in a medium along x-direction are given by

$$y_1 = \frac{1}{2 + (2x - 3t)^2}\, m \text{ and } y_2 = -\frac{1}{2 + (2x + 3t - 6)^2}\, m$$

where x is in metres and t is in seconds

(a) at $x = \frac{3}{2}$ m the resultant displacement will be zero at all times.

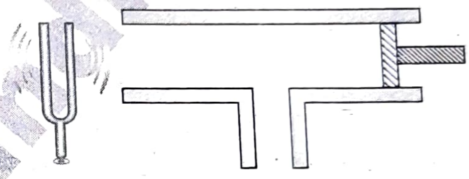
(b) at $t = 1$s which resultant displacement will be zero everywhere.

(c) Both waves travel along the same direction.

(d) Both waves travel in the opposite directions.

Fill in the Blanks Type

15. There is a destructive interference between the two waves of wavelength λ coming from two different paths at a point. To get maximum sound or constructive interference at that point, the path of one wave is to be increased by.........
16. When two sound waves with a phase difference of $\pi/2$, and each having amplitude A and frequency ω, are superimposed on each other, then the maximum amplitude and frequency of resultant wave is......
17. If the phase difference between the two waves is 2π during superposition, then the resultant amplitude is .....
18. The superposition takes place between two waves of frequency f and amplitude a. The total intensity is directly proportional is.......
19. If two waves of the same frequency and the same amplitude respectively on superimposition produced a resultant disturbance of the same amplitude, the wave differ in phase is.......
20. Two sound waves (expressed in CGS units) given by $y_1 = 0.3\sin\frac{2\pi}{\lambda}(vt - x)$ and $y_2 = 0.4\sin\frac{2\pi}{\lambda}(vt - x + \theta)$ interfere. The resultant amplitude at a place where phase difference is $\pi/2$......
21. If two waves having amplitudes $2A$ and A and the same frequency and velocity propagate in the same direction in the same phase, find the resulting amplitude....
22. The intensity ratio of two waves is 1 : 16. The ratio of their amplitudes is ......
23. Vibrating tuning fork of frequency n is placed near the open end of a long cylindrical tube. The tube has a side opening and is fitted with a movable reflecting piston. As the piston is moved through 8.75 cm, the intensity of sound changes from a maximum to minimum. If the speed of sound is 350 m/s. Then n is.



24. If the ratio of amplitude of two waves is 4 : 3, then the ratio of maximum and minimum intensity......

Answers Key

Single Correct Answer Type

1. (d) 2. (d) 3. (c) 4. (c) 5. (a)
6. (d) 7. (b) 8. (d) 9. (d) 10. (a)
11. (b) 12. (b) 13. (c)

Multiple Correct Answers Type

14. (a, b, d)

Fill in the Blanks Type

15. $\frac{\lambda}{2}$ 16. $\sqrt{2}\,A:\omega$ 17. Maximum
18. $4a^2$ 19. $2\pi/3$ 20. 0.5 cm
21. $3A$ 22. 1 : 4 23. 1000 Hz
24. 49 : 1

DPP 7.2

Beats

Single Correct Answer Type

1. An unknown frequency x produces 8 beats [illegible]conds with a frequency of 250 Hz and 12 beats with [illegible]) Hz source, then x is
(a) 258 Hz (b) 242 Hz (c) 262 Hz (d) 282 Hz

2. Two tuning forks when sounded together produced 4 beats/sec. The frequency of one fork is 256. The number of beats heard increases when the fork of frequency 256 is loaded with wax. The frequency of the other fork is
(a) 504 (b) 520 (c) 260 (d) 252

3. If two tuning forks A and B are sounded together, they produce 4 beats per second. A is then slightly loaded with wax, they produce 2 beats when sounded again. The frequency of A is 256. The frequency of B will be
(a) 250 (b) 252 (c) 260 (d) 262

4. The frequencies of two sound sources are 256 Hz and 260 Hz. At $t = 0$, the intensity of sound is maximum. Then the phase difference at the time $t = 1/16$ sec will be
(a) Zero (b) π (c) $\pi/2$ (d) $\pi/4$

5. When a tuning fork of frequency 341 is sounded with another tuning fork, six beats per second are heard. When the second tuning fork is loaded with wax and sounded with the first tuning fork, the number of beats is two per second. The natural frequency of the second tuning fork is
(a) 334 (b) 339 (c) 343 (d) 347

6. Tuning fork F_1 has a frequency of 256 Hz and it is observed to produce 6 beats/second with another tuning fork F_2. When F_2 is loaded with wax, it still produces 6 beats/second with F_1. The frequency of F_2 before loading was
(a) 253 Hz (b) 262 Hz (c) 250 Hz (d) 259 Hz

7. Beats are produced by two waves given by $y_1 = a \sin 2000\pi t$ and $y_2 = a \sin 2008\,\pi t$. The number of beats heard per second is
(a) Zero (b) One (c) Four (d) Eight

8. A tuning fork whose frequency as given by manufacturer is 512 Hz is being tested with an accurate oscillator. It is found that the fork produces a beat of 2 Hz when oscillator reads 514 Hz but produces a beat of 6 Hz when oscillator reads 510 Hz. The actual frequency of fork is
(a) 508 Hz (b) 512 Hz (c) 516 Hz (d) 518 Hz

9. Ten tuning forks are arranged in increasing order of frequency in such a way that any two nearest tuning forks produce 4 beats/sec. The highest frequency is twice of the lowest. Possible highest and the lowest frequencies are
(a) 80 and 40 (b) 100 and 50
(c) 44 and 22 (d) 72 and 36

10. Two identical flutes produce fundamental notes of frequency 300 Hz at 27°C. If the temperature of air in one flute is increased to 31°C, the number of the beats heard per second will be
(a) 1 (b) 2 (c) 3 (d) 4

11. The frequency of tuning forks A and B are respectively 3% more and 2% less than the frequency of tuning fork C. When A and B are simultaneously excited, 5 beats per second are produced. Then the frequency of the tuning fork 'A' (in Hz) is
(a) 98 (b) 100 (c) 103 (d) 105

12. Two tuning forks have frequencies 380 and 384 Hz respectively. When they are sounded together, they produce 4 beats. After hearing the maximum sound, how long will it take to hear the minimum sound
(a) $\frac{1}{2}$ sec (b) $\frac{1}{4}$ sec (c) $\frac{1}{8}$ sec (d) $\frac{1}{16}$ sec

13. When a tuning fork A of unknown frequency is sounded with another tuning fork B of frequency 256 Hz, then 3 beats per second are observed. After that A is loaded with wax and sounded, the again 3 beats per second are observed. The frequency of the tuning fork A is
(a) 250 Hz (b) 253 Hz (c) 259 Hz (d) 262 Hz

Answers Key

Single Correct Answer Type

1. (a) **2.** (c) **3.** (b) **4.** (c) **5.** (d) **6.** (b) **7.** (c) **8.** (c) **9.** (d) **10.** (b)
11. (c) **12.** (c) **13.** (c)

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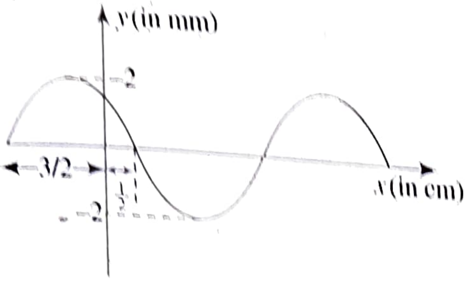
DPP 7.3

Stationary Waves

Subjective Type

1. A standing wave pattern of maximum amplitude 2 mm is obtained in a string whose shape at $t = 0$ is represented in the graph.



If the speed of the travelling wave in the string is 5 cm/s, then find the component waves.

Single Correct Answer Type

2. In a stationary wave all the particles
   (a) on either side of a node vibrate in the same phase
   (b) in the region between two nodes vibrate in the same phase
   (c) in the region between two antinodes vibrate in the same phase
   (d) of the medium vibrate in the same phase

3. When a stationary wave is formed, then its frequency is
   (a) same as that of the individual waves
   (b) twice that of the individual waves
   (c) half that of the individual waves
   (d) none of the above

4. At a certain instant a stationary transverse wave is found to have maximum kinetic energy. The appearance of string at that instant is
   (a) sinusoidal shape with amplitude $A/3$
   (b) sinusoidal shape with amplitude $A/2$
   (c) sinusoidal shape with amplitude A
   (d) straight line

5. Which two of the given transverse waves will give stationary waves when get superimposed?

$z_1 = a\cos(kx - \omega t)$ (A)

$z_2 = a\cos(kx + \omega t)$ (B)

$z_3 = a\cos(ky - \omega t)$ (C)

   (a) A and B (b) A and C
   (c) B and C (d) Any two

6. For the stationary wave $y = 4\sin\left(\frac{\pi x}{15}\right)\cos(96\pi t)$, the distance between a node and the next antinode is
   (a) 7.5 (b) 15 (c) 22.5 (d) 30

7. A wave represented by the given equation $y = a\cos(kx - \omega t)$ is superposed with another wave to form a stationary wave such that the point $x = 0$ is a node. The equation for the other wave is
   (a) $y = a\sin(kx + \omega t)$ (b) $y = -a\cos(kx + \omega t)$
   (c) $y = -a\cos(kx - \omega t)$ (d) $y = -a\sin(kx - \omega t)$

8. Two waves are approaching each other with a velocity of 20 m/s and frequency n. The distance between two consecutive nodes is
   (a) $\frac{20}{n}$ (b) $\frac{10}{n}$ (c) $\frac{5}{n}$ (d) $\frac{n}{10}$

9. Two sinusoidal waves with the same wavelengths and amplitudes travel in opposite directions along a string with a speed 10 ms^{-1}. If the minimum time interval between two instants when the string is flat is 0.5 s, the wavelength of the waves is
   (a) 25 m (b) 20 m (c) 15 m (d) 10 m

10. Consider the three waves z_1, z_2 and z_3 as $z_1 = A\sin(kx - \omega t)$, $z_2 = A\sin(kx + \omega t)$ and $z_3 = A$ sin $(kx - \omega t)$. Which of the following represents a standin wave?
   (a) $z_1 + z_2$ (b) $z_2 + z_3$ (c) $z_3 + z_1$ (d) $z_1 + z_2 + z_3$

11. Spacing between two successive nodes in a standing wav on a string is x. If frequency of the standing wave is kep unchanged but tension in the string is doubled, then ne spacing between successive nodes will become:
   (a) $x/\sqrt{2}$ (b) $\sqrt{2}x$ (c) $x/2$ (d) $2x$

12. A standing wave pattern is formed on a string. One of t waves is given by equation $y_1 = a\cos\left(\omega t - kx + \frac{\pi}{3}\right)$, th the equation of the other wave such that at $x = 0$ a node formed.
   (a) $y_2 = a\sin\left(\omega t + kx + \frac{\pi}{3}\right)$
   (b) $y_2 = a\cos\left(\omega t + kx + \frac{\pi}{3}\right)$
   (c) $y_2 = a\cos\left(\omega t + kx + \frac{2\pi}{3}\right)$
   (d) $y_2 = a\cos\left(\omega t + kx + \frac{4\pi}{3}\right)$

Multiple Correct Answers Type

13. In a standing wave on a string.

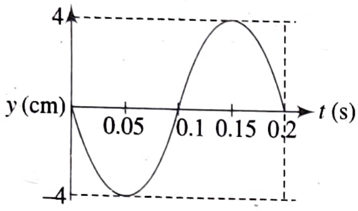
(a) In one time period all the particles are simultaneously at rest twice.

(b) All the particles must be at their positive extremes simultaneously once in one time period

(c) All the particles may be at their positive extremes simultaneously once in a time period.

(d) All the particles are never at rest simultaneously.

14. For a certain transverse standing wave on a long string, an antinode is formed at $x = 0$ and next to it, a node is formed at $x = 0.10$ m. The displacement $y(t)$ of the string particle at $x = 0$ is shown in the figure.



(a) Transverse displacement of the particle at $x = 0.05$ m and $t = 0.05$ s is $-\ 2\sqrt{2}$ cm

(b) Transverse displacement of the particle at $x = 0.04$ m and $t = 0.025$ s is $-2\sqrt{2}$ cm

(c) Speed of the travelling waves that interfere to produce this standing wave is 2 m/s

(d) The transverse velocity of the string particle at $x = \frac{1}{15}$ m and $t = 0.1$ s is 20 cm/s

Fill in the Blanks Type

15. The equation of stationary wave along a stretched string is given by $y = 5\sin\frac{\pi x}{3}\cos 40\pi t$, where x and y are in cm and t in second. The separation between two adjacent nodes is.............

16. A standing wave having 3 nodes and 2 antinodes is formed between two atoms having a distance 1.21 Å between them. The wavelength of the standing wave is ......

17. In stationary waves, distance between a node and its nearest antinode is 20 cm. The phase difference between two particles having a separation of 60 cm will be......

18. A standing wave is represented by
$Y = A\sin(100t)\cos(0.01x)$
where Y and A are in millimetre, t is in seconds and x is in metre. The velocity of wave is.........

19. A wave of frequency 100 Hz is sent along a string towards a fixed end. When this wave travels back after reflection, a node is formed at a distance of 10 cm from the fixed end of the string. The speed of incident (and reflected) wave is.........

Answers Key

Single Correct Answer Type

2. (b) **3.** (a) **4.** (d) **5.** (a) **6.** (a)
7. (b) **8.** (b) **9.** (d) **10.** (a) **11.** (b)
12. (d)

Multiple Correct Answers Type

13. (a, c) **14.** (a, c, d)

Fill in the Blanks Type

15. 3 cm **16.** 1.21 Å **17.** $3\pi/2$
18. 10^4 m/s **19.** 20 m/s

DPP 7.4

Vibration of String

Subjective Type

1. A 40 cm long wire having a mass 3.2 gm and area of cross section 1 mm^2 is stretched between the support 40.05 cm apart. In its fundamental mode, it vibrates with a frequency 1000/64 Hz. Find the Young's modulus of the wire in the form $X \times 108$ N-m^2 and fill value of X.

Single Correct Answer Type

2. A tuning fork vibrating with a sonometer having 20 cm wire produces 5 beats per second. The beat frequency does not change if the length of the wire is changed to 21 cm. The frequency of the tuning fork (in Hertz) must be
   (a) 200 (b) 210 (c) 205 (d) 215

3. In order to double the frequency of the fundamental note emitted by a stretched string, the length is reduced to $\frac{3}{4}$th of the original length and the tension is changed. The factor by which the tension is to be changed is
   (a) $\frac{3}{8}$ (b) $\frac{2}{3}$ (c) $\frac{8}{9}$ (d) $\frac{9}{4}$

4. A string of 7 m length has a mass of 0.035 kg. If tension in the string is 60.5 N, then speed of a wave on the string is
   (a) 77 m/s (b) 102 m/s (c) 110 m/s (d) 165 m/s

5. A second harmonic has to be generated in a string of length l stretched between two rigid supports. The points where the string has to be plucked and touched are
   (a) Plucked at $\frac{l}{4}$ and touch at $\frac{l}{2}$
   (b) Plucked at $\frac{l}{4}$ and touch at $\frac{3l}{4}$
   (c) Plucked at $\frac{l}{2}$ and touched at $\frac{l}{4}$
   (d) Plucked at $\frac{l}{2}$ and touched at $\frac{3l}{4}$

6. Two wires are fixed in a sonometer. Their tensions are in the ratio 8 : 1. The lengths are in the ratio 36:35. The diameters are in the ratio 4 : 1. Densities of the materials are in the ratio 1 : 2. If the lower frequency in the setting is 360 Hz. The beat frequency when the two wires are sounded together is
   (a) 5 (b) 8 (c) 6 (d) 10

7. A string is rigidly tied at two ends and its equation of vibration is given by $y = \cos 2\pi t \sin \pi x$. Then minimum length of string is
   (a) 1 m (b) $\frac{1}{2}$m (c) 5 m (d) 2 πm

8. Fundamental frequency of sonometer wire is n. If the length, tension and diameter of wire are tripled, the new fundamental frequency is
   (a) $\frac{n}{\sqrt{3}}$ (b) $\frac{n}{3}$ (c) $n\sqrt{3}$ (d) $\frac{n}{3\sqrt{3}}$

9. A string of length 2 m is fixed at both ends. If this string vibrates in its fourth normal mode with a frequency of 500 Hz, then the waves would travel on it with a velocity of
   (a) 125 m/s (b) 250 m/s (c) 500 m/s (d) 1000 m/s

Comprehension Type

For Problem 10 and 11

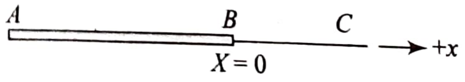
A string of length L, fixed at its both ends is vibrating in its 1st overtone mode. Consider two elements of the string of the same small length at positions $l_1 = 0.2$ L and $l_2 = 0.45$ L from one end.

10. If K_1 and K_2 are their respective maximum kinetic energies, then
    (a) $K_1 = K_2$
    (b) $K_1 > K_2$
    (c) $K_1 < K_2$
    (d) it is not possible to decide the relation

11. Follow situation of part (a). If k_1 and k_2 are respective force constants of their simple harmonic motions, then
    (i) $k_1 = k_2$
    (ii) $k_1 > k_2$
    (iii) $k_1 < k_2$
    (iv) it is not possible to decide the relation

For Problems 12 to 14

In the figure shown, a sinusoidal wave is generated at the end 'A'. The wave travels along positive x-axis and during its motion it encounters another string BC at the junction 'B' at $x = 0$. The density of strings AB and BC are ρ and 9ρ respectively and their radii of cross sections are $2r$ and r. The wave function, amplitude and wavelength of incident wave are respectively y_i, A_i and λ_i. Similarly for reflected and transmitted wave, these parameters are y_r, A_r, λ_r and y_t, A_t, λ_t respectively.



12. Which of the following statement regarding phase difference, $\Delta\phi$ between waves at $x = 0$ is true?
(a) $\Delta\phi = 0$, between y_i and y_r
(b) $\Delta\phi = 0$, between y_r and y_t
(c) $\Delta\phi = \pi$, between y_i and y_r
(d) $\Delta\phi = \pi$, between y_r and y_t

13. The ratio of wavelengths λ_r to λ_t (i.e. $\lambda_r : \lambda_t$) will be
(a) 1 : 1 (b) 3 : 2
(c) 2 : 3 (d) None of these

14. The ratio of amplitudes A_r to A_t is (i.e. $A_r : A_t$) will be
(a) 1 : 1 (b) 1 : 4
(c) 4 : 1 (d) None of these

Fill in the Blanks Type

15. A 1 cm long string vibrates with fundamental frequency of 256 Hz. If the length is reduced to $\frac{1}{4}$cm keeping the tension unaltered, the new fundamental frequency will be.......

16. Standing waves are produced in a 10 m long stretched string. If the string vibrates in 5 segments and the wave velocity is 20 m/s, the frequency is........

17. The velocity of waves in a string fixed at both ends is 2 m/s. The string forms standing waves with nodes 5.0 cm apart. The frequency of vibration of the string in Hz is........

18. A stretched string of 1 m length and mass 5×10^{-4} kg is having tension of 20 N. If it is plucked at 25 cm from one end, then it will vibrate with frequency......

19. Two similar sonometer wires have fundamental frequencies of 500 Hz. These have same tensions. By what amount the tension be increased in one wire so that the two wires produce 5 beats/sec ......

20. A string is producing transverse vibration whose equation is $y = 0.021 \sin(x + 30t)$, where x and y are in meters and t is in seconds. If the linear density of the string is 1.3×10^{-4} kg/m, then the tension in the string in N will be.........

21. Four wires of identical length, diameters and of the same material are stretched on a sonometre wire. If the ratio of their tensions is 1 : 4 : 9 : 16, then the ratio of their fundamental frequencies is ....

22. The fundamental frequency of a sonometre wire is n. If its radius is doubled and its tension becomes half, the material of the wire remains the same, the new fundamental frequency will be ......

23. Two uniform strings A and B made of steel are made to vibrate under the same tension. If the first overtone of A is equal to the second overtone of B and if the radius of A is twice that of B, the ratio of the lengths of the strings is ...

24. If you set up the seventh harmonic on a string fixed at both ends, the number of nodes and antinodes are set up in it will be........

Answers Key

Subjective Type

1. 1×10^9 Nm^2

Single Correct Answer Type

2. (c) **3.** (d) **4.** (c) **5.** (a) **6.** (d)
7. (b) **8.** (d) **9.** (c)

Comprehension Type

10. (b) **11.** (a) **12.** (d) **13.** (b) **14.** (b)

Fill in the Blanks Type

15. 1024 **16.** 5 Hz **17.** 20 **18.** 200 Hz
19. 2% **20.** 0.117 **21.** 1 : 2 : 3 : 4
22. $\frac{n}{2\sqrt{2}}$ **23.** 1 : 3 **24.** 8, 7

DPP 7.5

Organ Pipe (Vibration of Air Column)

Single Correct Answer Type

1. The length of two open organ pipes are l and $(l + \Delta l)$ respectively. Neglecting end correction, the frequency of beats between them will be approximately
   (a) $\frac{v}{2l}$ (b) $\frac{v}{4l}$ (c) $\frac{v\Delta l}{2l^2}$ (d) $\frac{v\Delta l}{l}$
   (Here v is the speed of sound)
2. Two closed organ pipes, when sounded simultaneously gave 4 beats per sec. If longer pipe has a length of 1 m. Then length of shorter pipe will be (v = 300 m/s)
   (a) 185.5 cm (b) 94.9 cm
   (c) 90 cm (d) 80 cm
3. A closed organ pipe and an open organ pipe are tuned to the same fundamental frequency. What is the ratio of lengths?
   (a) 1 : 2 (b) 2 : 1 (c) 2 : 3 (d) 4 : 3
4. On producing the waves of frequency 1000 Hz in a Kundt's tube, the total distance between 6 successive nodes is 85 cm. Speed of sound in the gas filled in the tube is
   (a) 330 m/s (b) 340 m/s (c) 350 m/s (d) 300 m/s
5. What is the base frequency if a pipe gives notes of frequencies 425, 255 and 595 and decide whether it is closed at one end or open at both ends?
   (a) 17, closed (b) 85, closed
   (c) 17, open (d) 85, open
6. Two closed organ pipes of length 100 cm and 101 cm give 16 beats in 20 sec. When each pipe is sounded in its fundamental mode, calculate the velocity of sound.
   (a) 303 ms^{-1} (b) 332 ms^{-1}
   (c) 323.2 ms^{-1} (d) 300 ms^{-1}
7. In a resonance pipe the first and second resonances are obtained at depths 22.7 cm and 70.2 cm respectively. What will be the end correction?
   (a) 1.05 cm (b) 115.5 cm
   (c) 92.5 cm (d) 113.5 cm
8. A tuning fork of frequency 340 Hz is vibrated just above the tube of 120 cm height. Water is poured slowly in the tube. What is the minimum height of water necessary for the resonance (speed of sound in the air = 340 m/sec)?
   (a) 15 cm (b) 25 cm (c) 30 cm (d) 45 cm
9. An organ pipe is closed at one end has fundamental frequency of 1500 Hz. The maximum number of overtones generated by this pipe which a normal person can hear is:
   (a) 14 (b) 13 (c) 6 (d) 9
10. The fundamental frequency of a closed pipe is 220 Hz. If $\frac{1}{4}$ of the pipe is filled with water, the frequency of the first overtone of the pipe now is
    (a) 220 Hz (b) 440 Hz (c) 880 Hz (d) 1760 Hz
11. A glass tube 1.5 m long and open at both ends is immersed vertically in a water tank completely. A tuning fork of 660 Hz is vibrated and kept at the upper end of the tube and the tube is gradually raised out of water. The total number of resonances heard before the tube comes out of water, taking velocity of sound air 330 m/sec is
    (a) 12 (b) 6 (c) 8 (d) 4

Multiple Correct Answers Type

12. It is desired to increase the fundamental resonance frequency in a tube which is closed at one end. This can be achieved by
    (a) replacing the air in the tube by hydrogen gas
    (b) increasing the length of the tube
    (c) decreasing the length of the tube
    (d) opening the closed end of the tube
13. An air column in a pipe, which is closed at one end, will be in resonance with a vibrating tuning fork of frequency 264 Hz, if the length of the column in cm is:
    (a) 31.25 (b) 62.50 (c) 93.75 (d) 125

Fill in the Blanks Type

14. A tube closed at one end and containing air is excited. It produces the fundamental note of frequency 512 Hz. If the same tube is open at both the ends the fundamental frequency that can be produced is...........
15. A closed pipe and an open pipe have their first overtones identical in frequency. Their lengths are in the ratio..........
16. If the velocity of sound in air is 336 m/s. The *maximum* length of a closed pipe that would produce a just audible sound will be ....
17. An air column in a pipe, which is closed at one end, will be in resonance with a vibrating body of frequency 166 Hz, if the length of the air column is .....
18. A cylindrical tube, open at both ends, has a fundamental frequency f_0 in air. The tube is dipped vertically into water such that half of its length is inside water. The fundamental frequency of the air column now is ....

19. Two closed pipes produce 10 beats per second when emitting their fundamental nodes. If their lengths are in ratio of 25 : 26. Then their fundamental frequencies in Hz are……

20. An open pipe resonates with a tuning fork of frequency 500 Hz. It is observed that two successive nodes are formed at distances 16 and 46 cm from the open end. The speed of sound in air in the pipe is …..

21. In a resonance tube the first resonance with a tuning fork occurs at 16 cm and second at 49 cm. If the velocity of sound is 330 m/s, the frequency of tuning fork is…….

22. In the 5th overtone of an open organ pipe, there are …… nodes and ……. antinodes.

Answers Key

Single Correct Answer Type

1. (c) **2.** (b) **3.** (a) **4.** (b) **5.** (b)
6. (c) **7.** (a) **8.** (d) **9.** (c) **10.** (c)
11. (b)

Multiple Correct Answers Type

12. (a, c, d) **13.** (a, c)

Fill in the Blanks Type

14. 1024 Hz
15. 3 : 4
16. 4.2 m
17. 0.50 m
18. f_0
19. 260, 250
20. 300 m/s
21. 500
22. 4, 5

8

Sound Wave and Doppler Effect

DPP 8.1

Doppler's Effect 1

Single Correct Answer Type

1. Two passenger trains moving with a speed of 108 km/hour cross each other. One of them blows a whistle whose frequency is 750 Hz. If sound speed is 330 m/s, then passengers sitting in the other train, after trains cross each other will hear sound whose frequency will be
(a) 900 Hz (b) 625 Hz (c) 750 Hz (d) 800 Hz

2. With what velocity an observer should move relative to a stationary source so that he hears a sound of double the frequency of source
(a) Velocity of sound towards the source
(b) Velocity of sound away from the source
(c) Half the velocity of sound towards the source
(d) Double the velocity of sound towards the source

3. A source of sound is moving with constant velocity of 20 m/s emitting a note of frequency 1000 Hz. The ratio of frequencies observed by a stationary observer while the source is approaching him and after it crosses him will be
(a) 9 : 8 (b) 8 : 9 (c) 1 : 1 (d) 9 : 10

4. A table is revolving on its axis at 5 revolutions per second. A sound source of frequency 1000 Hz is fixed on the table at 70 cm from the axis. The minimum frequency heard by a listener standing at a distance from the table will be (speed of sound = 352 m/s)
(a) 1000 Hz (b) 1066 Hz
(c) 941 Hz (d) 352 Hz

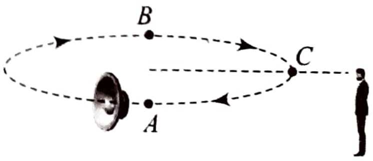
5. A source of sound *S* of frequency 500 Hz situated between a stationary observer *O* and a wall *W* moves towards the wall with a speed of 2 m/s. If the velocity of sound is 332 m/s, then the number of beats per second heard by the observer is (approximately)
(a) 8 (b) 6 (c) 4 (d) 2

6. A motor car blowing a horn of frequency 124 vib/sec moves with a velocity 72 km/hr towards a tall wall. The frequency of the reflected sound heard by the driver will be (velocity of sound in air is 330 m/s)
(a) 109 vib/sec (b) 132 vib/sec
(c) 140 vib/sec (d) 248 vib/sec

7. An observer standing at station observes frequency 219 Hz when a train approaches and 184 Hz when train goes away from him. If velocity of sound in air is 340 m/s, then velocity of train and actual frequency of whistle will be
(a) 15.5 ms^{-1}, 200 Hz (b) 19.5 ms^{-1}, 205 Hz
(c) 29.5 ms^{-1}, 200 Hz (d) 32.5 ms^{-1}, 205 Hz

8. Two sirens situated one kilometer apart are producing sound of frequency 330 Hz. An observer starts moving from one siren to the other with a speed of 2 m/s. If the speed of sound be 330 m/s, what will be the beat frequency heard by the observer?
(a) 8 (b) 4 (c) 6 (d) 1

9. A small source of sound moves on a circle as shown in the figure and an observer is standing on *O*. Let n_1, n_2 and n_3 be the frequencies heard when the source is at *A*, *B* and *C* respectively. Then



(a) $n_1 > n_2 > n_3$ (b) $n_2 > n_3 > n_1$
(c) $n_1 = n_2 > n_3$ (d) $n_2 > n_1 > n_3$

10. A source of sound of frequency 256 Hz is moving rapidly towards a wall with a velocity of 5 m/s. The speed of sound is 330 m/s. If the observer is between the wall and the source, then beats per second heard will be
(a) 7.8 Hz (b) 7.7 Hz (c) 3.9 Hz (d) Zero

11. The apparent frequency of a note, when a listener moves towards a stationary source, with velocity of 40 m/s is 200 Hz. When he moves away from the same source with the same speed, the apparent frequency of the same note is 160 Hz. The velocity of sound in air is (in m/s)
(a) 360 (b) 330 (c) 320 (d) 340

Fill in the Blanks Type

12. A source of sound of frequency 450 cycles/sec is moving towards a stationary observer with 34 m/sec speed. If the speed of sound is 340 m/sec, then the apparent frequency will be .....

13. An observer moves towards a stationary source of sound of frequency n. The apparent frequency heard by him is $2n$. If the velocity of sound in air is 332 m/sec, then the velocity of the observer is......

14. A person feels 2.5% difference of frequency of a motor-car horn. If the motor-car is moving to the person and the velocity of sound is 320 m/sec, then the velocity of car will be ......

15. A source of sound emitting a note of frequency 200 Hz moves towards an observer with a velocity v equal to the velocity of sound. If the observer also moves away from the source with the same velocity v, the apparent frequency heard by the observer is......

16. A source of sound is travelling towards a stationary observer. The frequency of the sound heard by the observer is of three times the original frequency. The velocity of sound is v m/sec. The speed of source will be......

17. A source and listener are both moving towards each other with speed $v/10$, where v is the speed of sound. If the frequency of the note emitted by the source is f, the frequency heard by the listener would be nearly......

18. Two trains are moving towards each other at speeds of 20 m/s and 15 m/s relative to the ground. The first train sounds a whistle of frequency 600 Hz. The frequency of the whistle heard by a passenger in the second train before the train meets is (the speed of sound in air is 340 m/s)......

19. A car sounding a horn of frequency 1000 Hz passes an observer. The ratio of frequencies of the horn noted by the observer before and after passing of the car is 11 : 9. If the speed of sound is v, the speed of the car is......

20. A boy is walking away from a wall towards an observer at a speed of 1 metre/sec and blows a whistle whose frequency is 680 Hz. The number of beats heard by the observer per second is (Velocity of sound in air = 340 metres/sec).........

21. When an engine passes near to a stationary observer, then its apparent frequencies occur in the ratio 5/3. If the velocity of engine is...........

Answers Key

Single Correct Answer Type

1. (b) **2.** (a) **3.** (a) **4.** (c) **5.** (b)
6. (c) **7.** (c) **8.** (b) **9.** (b) **10.** (a)
11. (a)

Fill in the Blanks Type

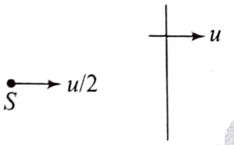
12. 500 cycles/sec **13.** 332 m/sec
14. 8 m/s (approx.) **15.** 200 Hz **16.** $\frac{2}{3}v$
17. $1.22f$ **18.** 666 Hz **19.** $\frac{1}{10}v$
20. 4 **21.** 85 m/s

DPP 8.2

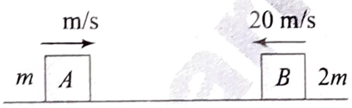
Doppler's Effect 2

Subjective Type

1. In a car race sound signals emitted by the two cars are detected by the detecter on the straight track at the end point of the race. Frequency observed are 330 Hz and 360 Hz and the original frequency is 300 Hz of both cars. Race ends with the separation of 100 m between the cars. Assume both cars move with constant velocity and velocity of sound is 330 m/s. Find the time taken by winning car.
2. A wall is moving with velocity u and a source of sound moves with velocity $\frac{u}{2}$ in the same direction as shown in the figure. Assuming that the sound travels with velocity $10u$. Find the ratio of incident sound wavelength on the wall to the reflected sound wavelength by the wall.

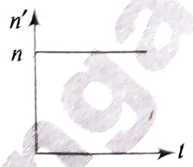


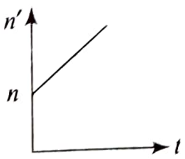
3. B is a source of sound of frequency 300 Hz. A and B collide head on. If the co-efficient of restitution is 1/2 and velocity of sound in air is 330 m/s, find the ratio of frequency appearing to A before collision and after collision.

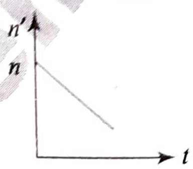


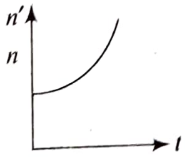
Single Correct Answer Type

4. An observer starts moving with uniform acceleration a towards a stationary sound source emitting a whistle of frequency n. As the observer approaches source, the apparent frequency heard by the observer varies with time as

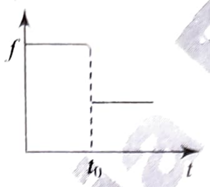
(a)


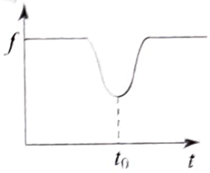
(b)


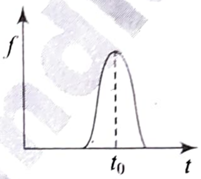
(c)


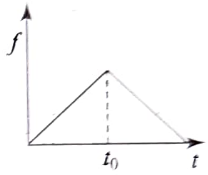
(d)


5. A man is standing on a railway platform listening to the whistle of an engine that passes the man at constant speed without stopping. If the engine passes the man at time t_0. How does the frequency f of the whistle as heard by the man changes with time?

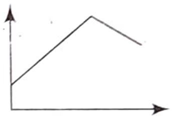
(a)


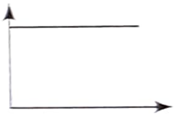
(b)


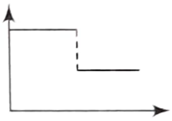
(c)


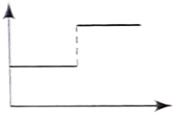
(d)


6. An observer approaches towards a stationary source of sound at constant velocity and recedes away at the same speed. The graph of wavelength observed with time is:

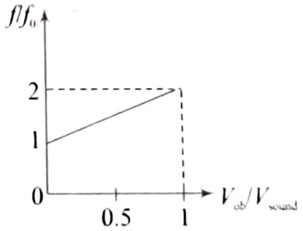
(a)


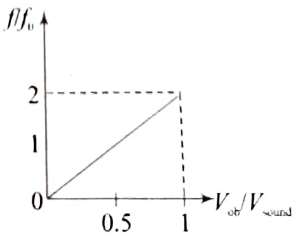
(b)


(c)


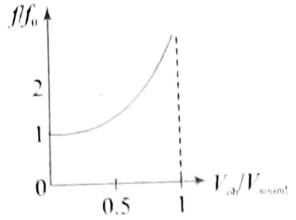
(d)


7. A curve is plotted to represent the dependence of the ratio of the received frequency f to the frequency f_0 emitted by the source on the ratio of the speed of observer V_{ob} to the speed of sound V_{sound} in a situation in which an observer is moving towards a stationary sound source. The curve is best represented by:

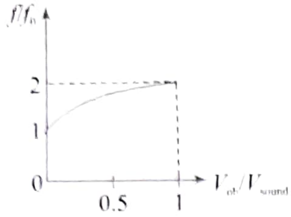
(a)


(b)


(c)



(d)



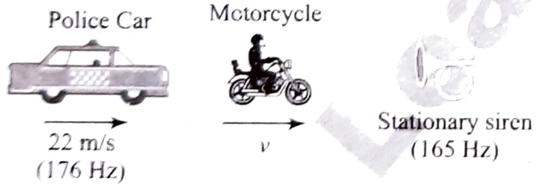
8. The difference between the apparent frequency of a source of sound as perceived by an observer during its approach and recession is 2% of the natural frequency of the source. If the velocity of sound in air is 300 m/sec, the velocity of the source is (It is given that velocity of source << velocity of sound)

(a) 6 m/sec (b) 3 m/sec
(c) 1.5 m/sec (d) 12 m/sec

9. Two cars are moving on two perpendicular roads towards a crossing with uniform speeds of 72 km/hr and 36 km/hr. If first car blows horn of frequency 280 Hz, then the frequency of horn heard by the driver of second car when line joining the cars make 45° angle with the roads will be

(a) 321 Hz (b) 298 Hz (c) 289 Hz (d) 280 Hz

10. A police car moving at 22 m/s, chases a motorcyclist. The police man sounds his horn at 176 Hz, while both of them move towards a stationary siren of frequency 165 Hz. Calculate the speed of the motorcycle, if it is given that he does not observes any beats



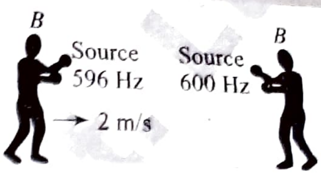
(a) 33 m/s (b) 22 m/s (c) Zero (d) 11 m/s

11. A car is initially at rest, 330 m away from a stationary observer. It begins to move towards the observer with an acceleration of 1.1 m/s², sounding its horn continuously. 20 second later, the driver stops sound the horn. The velocity of sound in air is 330 m/s. The observer will hear the sound of the horn for a duration of:

(a) 20 sec (b) 21 sec (c) 62/3 sec (d) 58/3 sec

Multiple Correct Answers Type

12. Two persons A and B each carrying a source of frequency 596 Hz and 600 Hz respectively are standing at rest a few metres apart. A starts moving towards B with a velocity of 2 m/s. If the speed of sound is 300 m/s. Which of the following statement is true?



(a) Beats heard per second by A is zero and B is 8.
(b) Beats heard per second by A is 8 and B is zero.
(c) Frequency of B heard by A is 604 Hz.
(d) Frequency of A as heard by B is 600 Hz.

13. A sound wave of frequency v travels horizontally to the right. It is reflected from a large vertical plane surface moving to the left with a speed v. The speed of sound in the medium is c, then study following statements

(a) The frequency of the reflected wave is $\frac{v(c+v)}{c-v}$
(b) The wavelength of the reflected wave is $\frac{c(c-v)}{v(c+v)}$
(c) The number of waves striking the surface per second is $\frac{v(c+v)}{c}$
(d) The number of beats heard by a stationary listener to the left of the reflecting surface is $\frac{v\,v}{c-v}$

14. A car moves towards a hill with speed v_c. It blows a horn of frequency f which is heard by an observer following the car with speed v_0. The speed of sound in air is v.

(a) The wavelength of sound reaching the hill is $\frac{v}{f}$
(b) The wavelength of sound reaching the hill is $\frac{v-v_c}{f}$
(c) The wavelength of sound of horn directly reaching the observer is $\frac{v+v_c}{f}$
(d) The beat frequency observed by the observer is $\frac{2v_c(v+v_o)f}{v^2-v_c^2}$

Answers Key

Subjective Type

1. 4 sec

2. $\frac{\lambda_i}{\lambda_r} = \frac{19u}{2f} \times \frac{18f}{11\times 19u} \times \frac{9}{11}$

3. $\frac{f_i}{f_a} = \frac{1105}{961}$

Single Correct Answer Type

4. (b) **5.** (a) **6.** (b) **7.** (a) **8.** (b)
9. (b) **10.** (b) **11.** (d)

Multiple Correct Answers Type

12. (b, c, d) **13.** (a, b, c) **14.** (b, c, d)